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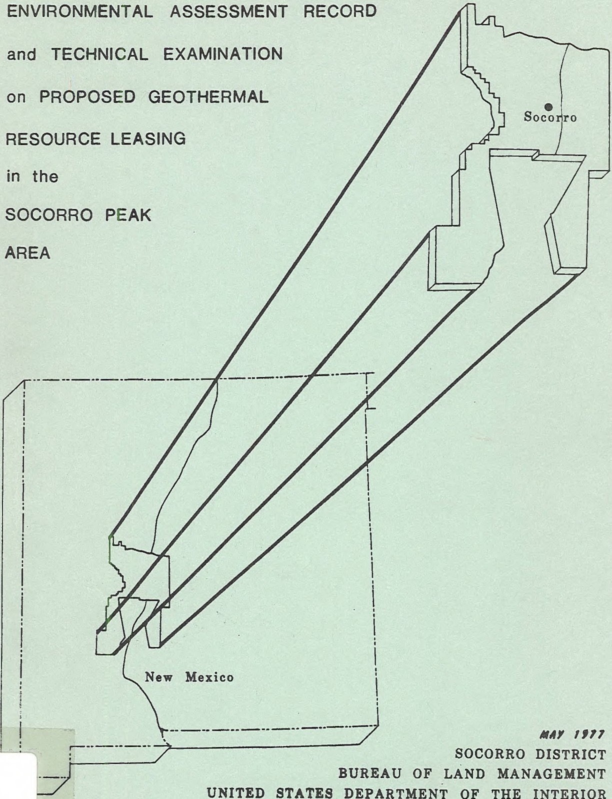

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UNITED STATES DEPARTMENT OF THE INTERIOR
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ENVIRONMENTAL ASSESSMENT RECORD and TECHNICAL EXAMINATION on PROPOSED GEOTHERMAL RESOURCE LEASING in the SOCORRO PEAK AREA

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I. DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

A. The Proposal

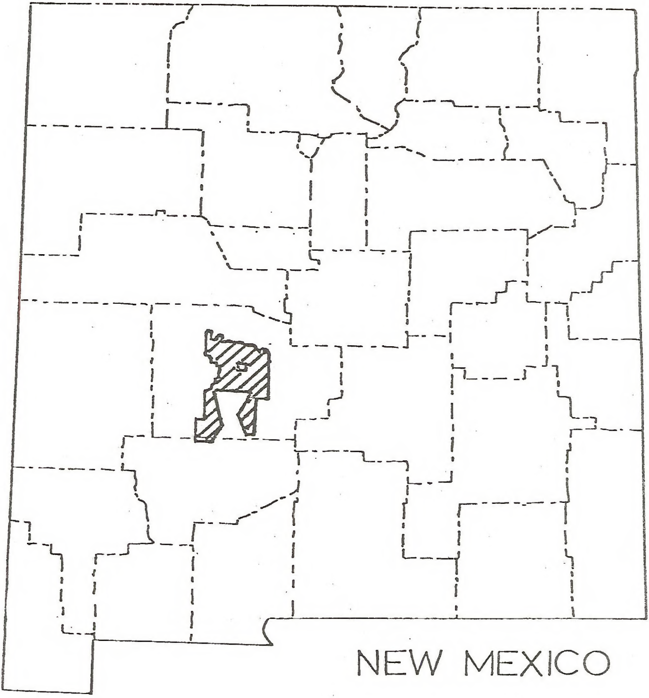
The proposed action is to offer for leasing approximately 365,463 acres (147,903 hectares) of National Resource Land, within the 624,814 acres area (252,868 hectares) known as the "Proposed Socorro Peak Geothermal Leasing Area", in Socorro, New Mexico for the purpose of exploration, development, and production of Federal geothermal resources (Map I-1). The proposed lease area completely encompasses the 89,716 acres (36,308 hectares) of land defined as the Socorro Peak Known Geothermal Resource Area (KGRA) by the U.S. Geological Survey (USGS) (Map I-2). The Socorro Grant was excluded from the proposed lease area because there is no National Resource Land within it. 4,901 acres (1,983 hectares) in the Elephant Butte Marsh are withdrawn from leasing by the U. S. Bureau of Reclamation. Non-competitive lease applications would be considered following 43 CFR 3210. Pre-lease casual use and exploration activities authorized under 43 CFR 3209 are also considered within this document.

No surface disturbance would be allowed on lease and permit areas that are, or would be considered sensitive areas. These areas include but are not limited to: critical wildlife habitat, critical watersheds, areas containing threatened or endangered plants or animals, archaeological sites, and outstanding natural areas.

Lands described within this Environmental Assessment Record (EAR) were selected because: the geology of the area suggests that there is good geothermal potential; and geothermal lease applications (18 applications for about 40,000 acres (16,188 hectares)) suggest interest by industry. This action is consistent with the Stallion Management Framework Plan decision which requires completion of an environmental analysis of the proposed leasing area.

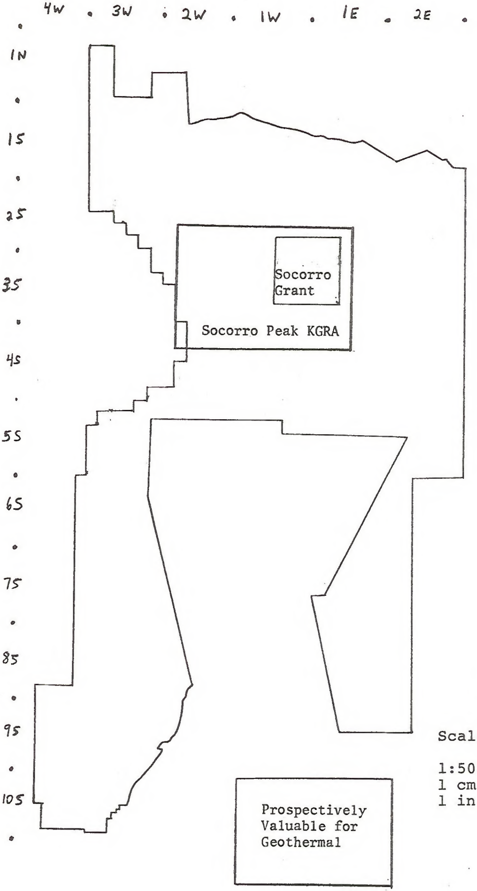
1. Stages of Implementation

When an area is selected for geothermal leasing, the Director of the Bureau of Land Management, or his authorized representative, requests that other interested bureaus and Federal agencies prepare reports describing, to the extent known, resources contained within the general area and the potential effect of geothermal development upon the resources of the area (43 CFR 3200.0-6(a)). The surface



MAP I-1

THE PROPOSED SOCORRO PEAK GEOTHERMAL LEASING AREA



MAP I-2

IDENTIFIED
GEOTHERMAL
AREAS

Scale

1:500,000
1 cm = 5 km
1 in. = approx. 8 mi

managing agency then makes a thorough evaluation of the environment and the resources through an Environmental Assessment Record (EAR) (43 CFR 3200.0-6(b)) and a Technical Examination (TE) (43 CFR 23.5). These evaluations consider the environmental impacts of developing geothermal resources. If the area is leased, the evaluation may recommend special stipulations which are not covered in the lease contract, 43 CFR group 3200, 30 CFR part 270-271, or GRO Orders.

Geothermal development of an area is divided into pre-lease exploration, competitive and non-competitive leasing, post-lease exploration, development, production, and close-out. A discussion of each phase would follow to acquaint the reader with the procedures and regulations associated with each phase (Tables I-1 through I-4). A glossary of terms used within this document is presented in Appendix A.

The progression from one phase to the next is dependent upon the success of each earlier stage. In practice, one phase often blends into another and it would be common for exploration and development to be undertaken in one part of a geothermal field; while a production operation was going on in another part of the field. Close-out of some wells, including rehabilitation, might also be taking place at the same time.

a. Pre-lease Exploration

Pre-lease exploration is divided into "Casual Use" and "Exploration Operations". Regulations that cover exploration are found in Geothermal Resource Operational (GRO) Order No. 1.

"Casual Use", as defined in 43 CFR 3209.0-5(d), means "activities" that involve practices which do not ordinarily lead to any appreciable disturbance or damage to lands, resources, and improvements." The activities do not involve vehicle movement, except, over established roads and trails. Casual use does not require a permit, EAR, or a surface protection technical examination. Geological reconnaissance, airborne surveys, geochemical surveys of existing wells and springs and non-surface disturbing geophysical prospecting are examples of casual use.

Exploration operations are defined in 43 CFR 3209.0-5(a) as any activity which requires physical presence upon public land and which may result in damage to public lands or resources. It may include, but is not limited to:

TABLE I-1

Stages of Implementation, Agency Responsibilities, and Regulations Associated with Geothermal Development

Stage of Implementation	BLM Responsibilities	USGS Responsibilities	Regulations
Pre-Lease Exploration	Review of "Notice of Intent to Conduct Geothermal Resource Exploration Operation" EAR and Technical Examination	Input	43 CFR 3209 Memorandum of Understanding, June, 1976 43 CFR 23.5
Leasing	EAR and Technical Examination (TE)	Input	43 CFR 3200 43 CFR 23.5
Post-Lease Exploration	Input	Plan of Operation Environmental Analysis (EA) Permit to Drill	43 CFR 3200 30 CFR 270-271 GRO Orders
Development	Input	Plan of Development EA Permit to Drill	3 CFR 3200 30 CFR 270-271 GRO Orders
Production	Input Permits for Power Lines, Pipelines, Power Plants, and Roads	Plan of Production EA Permit to Drill	43 CFR 3200 30 CFR 270-271 GRO Orders
	(Certificate of Public Convenience and Necessity from Public Utility Commission of New Mexico to construct Power Plant)		
Close-out	Input	Input	43 CFR 3200 30 CFR 270-271 GRO Orders

TABLE I-2

SUMMARY OF NOTICE OF INTENT PROCEDURES

Operator	USGS	Surface Management Agency (BLM/USFS/USBR)	U. S. Fish and Wildlife Service
Through field investigation, identify lands deserving of more intensive investigation not within normal use of public lands. Activities required are likely to impair land surface or fish and wildlife or habitat resources.			
Develops Notice of Intent for Permit to Conduct Exploration Operation (geothermal resources) which includes the description, location, and date of proposed activities. Submits Notice of Intent to the appropriate surface management agency. A bond is required with the Notice of Intent.			
		Reviews Notice of Intent for possible damage to land surface or resources, and for conformance to the multiple-use management responsibilities of the surface management agency. Submits Notice of Intent to the USGS for review. Bond is held.	
	Reviews Notice of Intent for safety and subsurface resource protection elements of the proposed activities. Recommends safety stipulations.		Reviews Notice of Intent for fish and wildlife resources protection. Recommends operational and rehabilitation requirements.
		Develops a set of stipulations to ensure safe and environmentally nondisruptive activities. Approves Notice of Intent. Thirty calendar days are allowed for review and determination.	
Conducts exploration activities. Upon completion of activities, submits a Notice of Completion of Exploration Operations to the surface management agency.			
		Reviews Notice of Completion and inspects lands to ensure that the stipulations were carried out satisfactorily.	
	Reviews Notice of Completion for protection of subsurface resources. Submits recommendations to the surface management agency.		Reviews Notice of Completion for protection of fish and wildlife resources and rehabilitation methods.
		Additional measures may be required of the operator. Ninety calendar days are allowed for this review. Surety bond is released upon satisfactory completion of requirements.	
	The Notice of Completion is held for files.		

TABLE I-3

SUMMARY OF NON-COMPETITIVE LEASING

Operator	USGS	BLM (and/or Surface Management Agency)	U. S. Fish and Wildlife Service
Through casual or Notice of Intent explorations, determines to lease lands which may be outside established KGRAs.			
Submits an application for non-competitive lease with complete description of lands to BLM.			
		BLM prepares serial register page and distributes it to USGS and to the appropriate surface management agency.	
		BLM screens applications of the current calendar period for overlap of interest. Refers areas with 50 percent overlap to USGS for KGRA designation. Refers areas to USGS for KGRA clearance.	
	USGS designates KGRAs when 50 percent overlap is involved. Applications are reviewed to determine if they are, in whole or in part, part of an existing KGRA.		
The operators who submitted applications which did not receive KGRA designation must submit a Plan of Exploration to BLM.			
		BLM distributes the Plan of Exploration to USGS and the surface management agency.	
	USGS provides geological and hydrological input to the EAR process.	The surface management agency conducts an EAR on the lands proposed for lease. Special lease stipulations are developed.	Provides fish and wildlife and ecological information for the EAR process.
	USGS reviews the EAR and adds special stipulations appropriate to drilling.		Reviews EAR for special lease stipulations regarding fish and wildlife.
		BLM prepares a lease with special stipulations and submits to operator for signing.	
Operator signs lease form and submits surety bond to BLM.			
		BLM forwards application to USGS for final KGRA clearing.	
	USGS reviews application to determine if it is part of an existing KGRA and for final concurrence with the stipulations.		
		BLM signs and issues non-competitive lease.	
Lessee is notified.			
		BLM distributes copies of the lease to USGS and surface management agency.	

TABLE I-4

SUMMARY OF COMPETITIVE LEASING

Operator	USGS	BLM (and/or Surface Management Agency)	U. S. Fish and Wildlife Service
	Designates KGRAs from geologic information and noncompetitive lease overlapping interests. List is published in *Federal Register*.		
		BLM-USFS-USBR-USGS develop priority listing of KGRAs to schedule processing and lease sales.	
	Provides geological information for the EAR process.	Surface management agency (BLM-USGS-USBR) develops an EAR on KGRAs and formulates special lease stipulations.	Provides fish, wildlife and ecological information for the EAR process.
	Reviews EAR, adding special USGS lease stipulations. Recommends parcelling, rent and royalty rates.		Reviews EAR for special lease stipulations regarding fish and wildlife.
		BLM state office publishes lease-sale notice.	
	Provides a pre-sale geothermal resource economic evaluation.		
		BLM state office holds lease sale.	
Bids are made on tracts within KGRAs.			
	Evaluation committee reviews bids and recommends acceptance or rejection.		
		BLM state office accepts or rejects bid.	
Highest bidder for a given tract submits Plan of Exploration.			
		BLM district office reviews Plan of Exploration for conformance with the EAR special stipulations. Copies are distributed to USGS and the surface management agency.	
		BLM state office prepares lease for highest bidder.	
Highest bidder signs lease and submits surety bond.			
		BLM state office issues lease and sends copies to USGS and the surface management agency.	

geophysical operations; drilling of shallow temperature gradient wells construction of roads and trails; and cross-country transit by vehicles over public lands.

A "Notice of Intent to Conduct Geothermal Resource Exploration Operations", accompanied by a $5,000 surety bond or a rider to a statewide or nationwide bond, must be filed for each "Exploration Operation" (43 CFR 3200.1-1 and 3209.4-1). Before any activity can commence, an EAR is written and the "Notice", which usually requires additional mitigating stipulations, is approved by the authorized officer. The required bond ensures compliance with regulations 43 CFR 3200. The stipulations are then attached to the "Notice". After exploration has been concluded, a "Notice of Completion of Geothermal Exploration Operations" must be filed. Within 90 days after the "Notice of Completion" is filed, a compliance inspection is made of the area and the party is notified whether they have complied with all the regulations and stipulations.

For convenience, exploration activities (as they relate to surface damage) may be classified into five discrete operations, four of which require physical presence on the land. In practice, several of these operations may be going on concurrently. The technique is to start by evaluating large areas (i.e., several townships) and gradually reduce the area of interest to select a target for drilling. As the area of interest is reduced, more intensive exploration techniques are employed.

Airborne Exploration - Involves a series of techniques including: aerial photography, for geologic interpretation; imagery, infrared to detect heat differentials; microwave to detect soil moisture differentials; magnetic, airborne magnetometer measures variations in the magnetic intensity of the earth; gravity, airborne gravimeter measures variations in the gravity field of the earth.

All of these techniques are attempts to gain data on the subsurface geology of an area. The data gathered must be interpreted by specialists and may supply clues as to areas deserving of more detailed studies. Airborne exploration produces no surface disturbance. It creates only a temporary negligible impact on air quality and noise levels.

Off-Road Vehicular Travel - Many exploration techniques require off-road vehicular travel in various degrees. Generally, existing roads are used where possible. Techniques which sometimes require cross-country travel include:

geological mapping, one or more small vehicles transport geologists to the work area; geophysical exploration, includes a number of techniques seeking clues as to underground geology.

Ground gravity surveys involve obtaining gravity readings along a surveyed grid with a portable gravimeter. A three-man crew does the work (two survey, and the third records gravity readings). One or two small trucks transport the crew and equipment to the work area.

Magnetic variations are measured with a magnetometer. The field technique is similar to the gravity determination.

Seismic shock waves are generated and measured along a grid system (generally 1 to 2 mile (1.6 to 3.2 kilometers) grid). Receivers (geophones) pick up seismic waves generated at a specific point on the grid. The seismic waves are generated by one of three methods:

> Vibration Method - Vibrations are produced by truck mounted vibrators, usually four, which operate in unison.
>
> Thumping Method - A truck-drawn or self-propelled unit containing a heavy weight or "hammer", drops the hammer on the ground to produce shock waves.
>
> Explosive Method - A truck-mounted rotary drill is used to drill holes 100 to 200 feet (30 to 60 meters) deep. These holes are loaded with 5 to 50 pounds (2.2 to 22 kilograms) of explosives and detonated (shot) to produce the elastic waves.

In all three seismic methods, 5 to 7 trucks and 10 to 15 men are required. Surface mineral matter and vegetation must be removed from the energy generation sites (shot points) and receiving sites (geophones) to provide for the maximum amount of energy to be sent and received. In addition, the explosive method often requires road construction, blading of lines, and clearing of small areas for drill operation.

All three seismic methods involve varying degrees of surface disturbance. The explosive method produces the most intense surface disturbance. Only the explosive method possesses the potential for subsurface impact (damage to nearby water wells, damage to near-surface aquifers, etc.), and then, only within a limited radius of the shot point.

Microseismic - Small geophones called seismometers are buried at a shallow depth and transmit normal extremely minor seismic activity (micro-earthquakes) to an amplifier on the surface. The amplifier is about the size of a suitcase. Locations are set up away from roads to avoid traffic "noise". These units are often backpacked into areas inaccessible to vehicles.

Resistivity - Induced polarization (IP) techniques are used to measure the resistance of subsurface rocks to the passage of an electrical current. A vehicle mounted transmitter sends pulses of electrical current into the ground through two widely spaced electrodes (usually about two miles apart). The behavior of these electrical pulses as they travel through underlying rocks is recorded by "pots" (potential electrodes), small ceramic devices that receive the current at different locations. The electrodes are either short rods (2 to 3 feet, 0.6 to 0.9 meter) driven into the ground, or aluminum foil buried to a shallow depth over an area of several square feet (square meters). Two or three small trucks transport the crew of 3 to 5 men to transmitting and receiving sites.

Telluric - A string of pots record the variations in the natural electrical currents in the earth. No transmitter is required. Small trucks are used to transport the crew to the work area.

Radiometric - Radioactive emissions (usually, radon gas) are measured as an indication of subsurface steam. Such measurements are usually made in the vicinity of hot springs, hence, existing roads are used. Measurements are taken with a hand-held scintillometer.

Geochemical Surveys - Includes the sampling of spring water to determine dissolved solid content (acidity, Na/K/Ca ratio and silica content) and the taking of small (hand trowel) surface soil and rock samples on a grid system to determine introduced mineralization and source areas for recharge. Occasionally, small trucks are used to transport the crew (usually 2 to 3 men) and equipment to the work area.

Road and Trail Construction - For exploration activities using large equipment in rough terrain with poorly developed access, roads and trails are often constructed. Since they are intended to provide only temporary access for such equipment as small drilling rigs and water trucks, they are usually constructed to a very low standard, generally a 10-foot (3 meters) wide dozer trail is used in dry, stable country. Where larger drilling equipment is to be used for an exploratory (wildcat) well, a considerably higher road standard may be employed.

Drilling - Several types of drill holes are used in the exploration phase. The size of the equipment used and the surface area needed differ with each drill hole. Rotary drilling, which employs the principle of a rotating vertical pipe (drill stem) upon which has been mounted a rock bit designed to chip rock as it rotates under pressure is often used. Drill cuttings or chips produced, as the hole progresses, are removed from shallow shot-holes by introducing a jet of air during drilling. For deeper drilling, a circulating medium of water or drilling mud is used to cool and lubricate the bit as well as to return the drill cuttings to the surface. Drilling mud helps prevent caving by plastering and consolidating the walls of the hole with a clay lining, thereby making casing unnecessary during shallow drilling.

Seismic test holes 100 to 200 feet (30 to 60 meters) deep are drilled with small truck-mounted rigs. Cuttings are removed by compressed air. The surface area used is just sufficient for the truck and equipment. An area of about 30 x 30 feet (9 x 9 meters) is disturbed by the operation. No specific drill pad is built.

Temperature gradient holes and shallow geologic information holes 300 to 500 feet (90 to 150 meters) deep are drilled with a small truck-mounted rig. The holes are usually between 4 and 6 inches (10 to 15 centimeters) in diameter. Mud is employed to remove the cuttings, and generally a portable metal mud pit is used to contain the mud. An area of about 30 x 30 feet (9 x 9 meters) is disturbed by use of the drill rig and servicing water truck.

Upon completion of the temperature gradient hole a capped pipe (usually 3/4-inch (1.9 centimeters) diameter) is placed in the hole, and let stand for about a week. Water in the pipe is heated by the temperature of the surrounding rock. Because of the small diameter of the pipe, convection currents do not form, hence, the water temperature in the pipe varies with depth. The temperature at different depths is measured by a thermistor probe on a cable.

Rehabilitation - Rehabilitation activities vary with terrain, climate, and significance of the damage.

Off-road vehicular travel requires no rehabilitation because the disturbance is temporary and, in most areas, heals itself in a short time.

Road and trail construction requires no rehabilitation unless there is a definite requirement for it (i.e., erosion hazard, access where none is wanted, etc.,). Where needed, such roads and trails can be scarified and reseeded if the site is susceptible to revegetation.

Small drill hole sites (seismic test holes, temperature gradient holes, information holes) are usually rehabilitated by cleaning up any debris and smoothing the area with a bulldozer where needed. Mud pits are filled and leveled. Where climate and terrain permit, revegetation could be accomplished.

b. Leasing

The process of leasing Federal geothermal resources is separated into competitive (43 CFR 3200) and non-competitive (43 CFR 3210) leasing.

A "Plan of Exploration" is required by 43 CFR 3210.2-1(d) and 43 CFR 3220.6(d). This plan should describe briefly the activities that would be conducted on the lands within the application.

The Geothermal Resource Lease Contract (BLM Form 3200-21) allows the Federal Government to lease geothermal resources and, at the same time, provides protection for other natural resources. Provisions within the contract require protection of the environment, antiquities, historic values, etc., in compliance with Federal Regulations (43 CFR, parts 3000 and 3200, and 30 CFR 270 and 271; GRO Orders, and any written or oral orders of the geothermal supervisor). In addition, special stipulations needed to protect unique values of a particular area may be incorporated into the lease contract and compliance becomes mandatory. GRO Order No. 4 indicates general environmental protection requirements for post-lease operations.

c. Post-lease Exploration

After a lease is issued, Federal regulations under 30 CFR 270.34 and 43 CFR 3203.6 require that a "Plan of Operation" be filed and approved by the land management agency and the U.S. Geological Survey before any activity other than "casual use" may commence. The "plan" with maps would discuss all exploration activities that would be conducted on the leased lands. The U.S. Geological Survey, the lead agency, studies the "plan" and sends copies to the surface managing agency and other interested agencies for comments.

The USGS must prepare an Environmental Analysis(EA) covering the specific site within the proposed "Plan of Operation". The EA is completed after input is obtained from a Geothermal Environmental Advisory Panel. The "Plan of Operation" must be jointly approved by the area geothermal supervisor and the appropriate land management agency. This includes any special conditions or stipulations deemed necessary to protect the environment, conform with the proper operational procedures, and consider multiple use management.

The lessee's application(s) for "Permit to Drill" (Form 9-331C), including any special stipulations as well as GRO Orders Nos. 2 and 4, is then issued to the lessee. The lessee may then start only those operations authorized under an approved "Plan of Operation". The lessee's authorized operations are continuously monitored and inspected by the area geothermal supervisor to ensure that the lessee complies with the applicable regulations.

Pre-lease exploration methods have been defined previously; however, post-lease exploration uses many of these methods on a more intensive basis. Exploratory drilling methods requiring depths of more than 500 feet (152 meters) also may be used. These include geological information holes and exploration wells.

Geologic Information Holes - These holes are similar to those drilled for temperature gradient purposes. Larger equipment is employed and a surface area of about 40 x 60 feet (12 x 18 meters) may be used. The cuttings are examined and the hole is probed with geophysical instruments to acquire data on the rock types and structure. Because these holes may extend to 1000 feet (304 meters) or more, a larger mud pit is needed. Typically, a mud pit is scooped out with a bulldozer. These pits may be 10 to 20 feet (3 to 6 meters) wide by 30 to 50 feet (9 to 15 meters) long by 3 to 6 feet (0.9 to 1.8 meters) deep depending on the terrain and the depth of the hole.

Exploration Wells - These wells are the same as development and production wells. If successful, they are generally converted to production. Drilling equipment, technology, and methods are similar to those used in oil and gas operations. Well bores of up to 24 inches (61 centimeters) in diameter at the top and 9 5/8 inches (25 centimeters) at the bottom may be drilled to depths of 5,000 to 10,000 feet (1,524 to 3,248 meters).

Mud is usually used for the drilling. Where water flows are not encountered, compressed air may be substituted as the circulation medium. At the Geysers dry steam field, for example, mud is used to the depth that temperature interferes with proper operations, then compressed air is used. Noise created during the air drilling operation is intense and approximates that of an unmuffled diesel truck.

A drill pad is leveled and cleared of vegetation. This involves a surface area of from less than one acre (0.4 hectares) up to two acres (0.8 hectares). The ancillary equipment is also located on the drill pad. A reserve pit of approximately 1,000 to 10,000 square feet (92 to 920 square meters) and 6 to 8 feet (1.8 to 2.4 meters) deep is sometimes dug to contain waste fluids and drill cuttings during drilling operations.

The well is cemented and cased and a blow-out preventer is installed to control sudden surges of pressure.

Blow-outs are uncommon, but do occur. The basic problem is a lack of knowledge of the specific characteristics of a geothermal field. During the pioneering development in many fields around the world, blow-outs seem to have occurred in 1 to 3 percent of the test and production wells drilled. At the Geysers there have been three blow-outs with over 100 wells drilled. Landslides in that steep terrain caused much of the problem. Geothermal blow-outs cause no fire hazard and are usually controlled by slant drilling and sealing with concrete.

While the blow-out is taking place, water, steam, and contained elements are wasted and spread on the surrounding land.

The release of pressure and water through drill holes may affect the surface expression of the geothermal field. Springs and geysers may dry up, increase, or be renewed in a different place. Accurate prediction of the results of drilling on such surface features cannot be made.

Since geothermal reservoirs are typically in active fault areas, normal earthquakes also occasionally change the surface features by drying up, moving or increasing thermal activity. It is, thus, not always possible to determine whether the observed effect was caused by drilling or by natural action.

During testing and venting, steam, fluids, and gases would be produced at the surface and proper precautions would be necessary to prevent surface pollution. The odor of hydrogen sulfide is often present at this point of exploration.

After the testing is completed, the drilling rig is removed and a "Christmas tree", a series of valves, is attached to the casing head and the disturbed area, then, is rehabilitated. If the well is abandoned, it must be plugged and rehabilitated according to GRO Order No. 3. All drilling operations must comply with GRO Order Nos. 2 and 4.

d. Development

Development includes all activities, from the decision to develop a producing field, until commercial power generation and transmission is reached. These operations are conducted only under a geothermal lease (either competitive or noncompetitive).

Five discrete operations, as they relate to surface disturbance are recognized, and many of these operations would normally be taking place concurrently.

Road Development - During development, roads to drill sites, power plant sites, and along transmission line routes may be constructed. Roads to producing wells and power plants would be permanent and may be surfaced and stabilized. Culverts would be used to avoid erosion of the road bed where necessary. Temporary roads to drill sites and for construction of power lines would, generally, be built to a low standard.

Drill Site Development - Wells drilled during the development stage would be similar to exploration wells. Often, somewhat larger equipment is used. The drill pad is leveled and cleared of vegetation. Generally, from less than one up to two acres are disturbed. A reserve pit (sump) 1,000 to 10,000 square feet (92 to 920 square meters) and 6 to 8 feet (1.8 to 2.4 meters) deep is sometimes dug to contain waste fluids during the drilling operations. The sump may be fenced to keep out animals.

About 500 to 1,000 barrels (1 barrel = 42 gallons = 159 liters) of water per day would be used in drilling a well. This water may come from water wells drilled in the immediate vicinity (about 60 gpm (227 liters per minute) flow would be adequate), from nearby surface water, or it may be hauled in by truck..

Current geothermal plants require a steam pressure about 100 psi (7 kilograms/square centimeter) at the generator. This places a limit the distance steam can be piped to the generator due to heat loss. Wells are, therefore, generally within one-half mile (0.8 kilometers) of the generation plant. The number of wells used to service a plant is dependent on the temperature of the wells (a temperature of 325 to 350 degrees F (163 to 177 degrees C) at the generator is needed) and the characteristics of the geothermal reservoir. Generally, 16 to 20 producing wells are used per power plant.

At Cerro Prieto, 18 wells (3 are standby) would service a 75 mw generating plant. They are drilled on a 10-acre (4 hectares) spacing (one well per 10 acres) (4 hectares). A 40-acre (16 hectares) well spacing is being used at the Geysers initially, but future drilling on 20-acre (8 hectares) spacing is planned in order to maintain steam production to plant capacity.

Production Testing - To determine the sustained flow characteristics of a well, and to clean out the hole, each new well is vented to the atmosphere for a period of time. Steam, water, and noise accompany production testing. The water is generally directed into the reserve pit and is contained. The steam is released into the atmosphere. Noncondensible gases and vapors are often contained in the steam. These vapors and gases make up generally less than 3 percent of the total steam fraction. When present in excessive amounts, some of these gases and vapors are toxic.

Gas	Toxicity Levels
Ammonia	550 ppm
Boric acid	None established
Carbon dioxide	5,000 ppm
Carbon monoxide	100 ppm
Hydrogen sulfide	20 ppm
Mercury	12.2 ppm
Methane	10,000 ppm

Where present in unacceptable amounts, monitoring devices and special precautions may be necessary as a safety measure. Additonally, very small amounts of hydrogen sulfide, as small as 0.025 parts per million (ppm) can be detected by smell. This "rotten egg" odor, common in hot spring areas, can be an aesthetic problem.

High noise levels accompany production testing. Because of this, muffling devices are usually installed. At the Geysers, measurements of noise from a muffled testing well indicate a noise level slightly less than that of an unmuffled diesel truck. Noise levels from other geothermal fields, both vapor dominated and water dominated, may not be of a similar magnitude.

Blow-outs in the four geothermal areas in the world (Geysers, USA; Lardarello, Italy; Wairakei, New Zealand; Cerro Prieto, Mexico) which have undergone commercial development, have occurred in approximately 1 to 3 percent of the wells drilled. These blow-outs were mostly in the exploratory or early stages of development drilling; with few mishaps in later stages as experience was gained and local drilling techniques perfected. Although some of these blow-outs were temporarily spectacular, none have resulted in any significant or lasting environmental damage. At Lardarello, Italy, the oldest commercial geothermal field in the world, the blow-outs are routinely handled as a noisy, difficult part of regular operations. They are not considered as serious mishaps that could cause pollution or have other adverse effects.

Geothermal Pipelines - Pipelines 10 to 30 inches (25 to 76 centimeters) in diameter would be used to transmit steam or hot water from the production wells to the power plants. The pipes are typically insulated with fiberglass or asbestos to minimize heat loss. Expansion loops or joints are placed at frequent intervals, either vertically or horizontally, to provide for the extreme expansion and contraction of the pipes upon production startup (heating up) and shutdown (cooling down). Under present technology, pipelines are constructed above ground to provide for expansion and contraction and to enhance maintenance and detection of leaks. Underground installation is, thus far, uneconomical and may also present some safety hazards. The lines form a radiating pattern on the surface, connecting wells with the power plant. They may be painted to blend with the surroundings.

Plant Construction - Generating plants are centrally located to minimize the length of the steam lines or water pipes from the servicing wells. The largest plants in current use consist of two 55 mw generators housed together so that production is 110 mw per power plant. Power plant spacing is about one plant per 640 acres (259 hectares) throughout the productive area. At the Geysers, the average 110 mw plant building is about 100 feet x 200 feet (30 x 60 meters) and three stories high. The adjacent cooling towers are about a third larger than the generating plant building. The entire generating plant cooling tower complex occupies an area of about five acres (2 hectares).

Transmission Lines - Power generated from the plant is transmitted via conventional powerlines to the area of use. The size and location of the lines is dependent upon the power output and destination. The lines would tend to be large, considering that 1 mw of plant capacity would service the power needs of about 1,000 people. To express this another way, one 110 mw power plant could supply the power needs of the City of Reno.

Rehabilitation - Rehabilitation would be possible on disturbed areas not needed for continued production, commensurate with terrain, climate, and significance of the damage.

Roads needed for maintenance and further development would not be rehabilitated. Temporary roads and trails can be scarified and revegetated, if desirable.

Drill sites require an area approximately 30 feet x 30 feet (9 x 9 meters) directly surrounding the well head for operation. An additional graded area about 50 feet x 100 feet (15 x 30 meters) may be needed for moving in a drilling rig to correct any problems which may develop during production. The reserve pit (sump) is generally dried out, covered with dirt, and graded. It and the remaining area of the drill site can be rehabilitated and revegetated.

Plant construction disturbance, during construction of the generating plant and cooling towers, can be rehabilitated and revegetated. The buildings may be painted to blend with the surroundings. Some cooling towers are architecturally attractive and, if desired, may be intentionally painted to contrast with the surroundings to heighten the visual experience.

Geothermal pipelines may be painted to blend with the surroundings, and any areas not needed for access may be revegetated. At Lardarello, Italy, steam lines cross grainfields and vineyards with, essentially, no loss of land productivity.

Transmission line surface disturbance may be rehabilitated with the exception of needed maintenance roads.

e. Production

The production phase starts upon reaching commercial power production. Exploration and development are typically carried on in other parts of the geothermal field simultaneously with the operational activities. The production stage may be divided into the following discrete operations.

(1) New Drill Sites - Geothermal fields are long lived resources. The Lardarello field has been in production since 1904 and the Geysers since 1958. The Geysers is estimated to have a minimum productive life of 30 or more years. Nonetheless, production slowly diminishes the heat flow and additional wells must be drilled and completed to keep the generating plant operating at full capacity.

Additional wells may also be required to replace wells that have become inoperative and, if the waste waters are disposed of by injection, injection wells may be drilled. The drilling technique and environmental effect would be the same as for development wells. On a major producing field, it can be expected that one or two drilling rigs would be operating continuously throughout the life of the field drilling additional or replacement wells.

(2) Maintenace - Repair, maintenance, and monitoring of an operating field would require the periodic use of access roads to service the equipment. Existing wells would require occasional repair work or cleanout. The amount of this remedial work would depend upon the production characteristics of the field; severe scaling and corrosion would require frequent remedial work. Normally, one medium-sized drill rig would be required full-time for each 20 to 30 wells (one 110 mw power plant).

(3) Waste Disposal - The work force (both construction and maintenance) for geothermal power plants would usually be housed in the nearest town rather than creating a new town at the site. Thus, waste materials connected with

human habitation would, typically, be handled in the local community.

At the plant site itself, sanitary facilities for workers would be provided. Solid wastes would either be disposed of in a dump developed at the site, or trucked to the nearest established dump site. The most significant waste disposal problem relates to handling the excess geothermal fluids. In vapor dominated systems, as at the Geysers, about 75 to 80 percent of the water from the spent steam is consumed in the cooling towers, leaving 20 to 25 percent to be disposed of. In water dominated systems, such as Cerro Prieto, the reverse is true with 80 percent or more of the total well production requiring disposal.

Disposal techniques vary, depending on the quality and quantities involved. Any or a combination of the following techniques may be employed:

> Evaporation Ponds - Waste water at Cerro Prieto is piped to evaporation ponds. Where water quality is satisfactory, such ponds may provide new aquatic habitat. Where water quality is toxic, special measures may be required to protect the groundwater supply, livestock, and wildlife.
>
> Natural Drainage Systems - At Wairakei, New Zealand, waste water is discharged into a large river. High quality water disposed of in this manner provides additional resources for agriculture, wildlife, and other uses. Low quality water may require extensive treatment before it is suitable for release into natural drainages.
>
> By-product Development - In some instances, it may be economical to extract useful minerals or gases from the geothermal fluids. This could result in increasing the waste water quality so as to make it available for other purposes.
>
> Desalinization may also be feasible in some areas, providing by-product fresh water for other areas.
>
> Re-injection - At the Geysers, excess water is re-injected into nonproductive zones of the geothermal field. Successful re-injection is dependent on the quality of the waste water and the geologic characteristics of the geothermal field. Typical considerations would include: whether plugging and scaling

problems would prevent the reservoir from accepting the fluid; whether fresh water aquifers can be adequately protected from contamination by hot saline waste water; and whether the subsurface rock structure would adequately hold the re-injected fluids.

(4) Production of Electricity - Production from a geothermal field would generally require 2 to 5 people per plant to inspect, adjust and service the wells, making the rounds about once each day on the existing road network. Sustained production would have several effects:

Temperature Drop - The field would gradually realize diminishing temperatures as the energy is used.

Water Utilization - Cooling towers would consume about 40 to 45 acre-feet (4.9 to 5.6 hectare-meters) of water per year for each megawatt of plant capacity. Each 110 mw plant would, thus, consume about 5,000 acre-feet (616.6 hectare-meters) of water per year. The water may come either from steam condensate, waste geothermal water, or from any other water source. This water consumption might be reduced by use of some technique other than conventional cooling towers. One such scheme, called the "night stream cooling system" would theoretically use only 42 percent as much water.

Subsidence - As large volumes of water are pumped from a geothermal reservoir, some subsidence of the ground surface may occur. In many cases, subsidence may have no serious land use or environ mental consequences. In some situations, such as developed agricultural land under gravity irrigation, minor surface subsidence could have a significant impact. Continuous monitoring might be necessary to detect whether subsidence was occurring. In some instances, re-injection of the waste water might correct subsidence problems.

Seismic Activity - Geothermal areas are typically associated with seismic activity. Such activity is generally of small magnitude (usually less than 4.5 on the Richter scale). Earthquakes sometimes modify geyser activity and may affect other geothermal features such as hot springs.

f. Close-out

Close-out or final abandonment takes place when energy production ceases to be economic. To date, no developed geothermal field has reached this stage. Geothermal reservoirs may be somewhat renewable resources in that after a long period of rest, the fluids may become reheated to temperatures that are again usable. Two discrete operations are expected to take place during close-out.

(1) Removal of Improvements - The removal of improvements from a geothermal field involves:

Surface Improvements - Removal of all structures constructed during field development and operations would be accomplished. Any remaining solid waste may either be disposed of in a dump developed at the site, or trucked to the nearest established dump.

Wells - The bottom of the hole is plugged with cement. The surface casing would also be plugged with about 20 feet (6 meters) of cement. The casing would be cut off below the surface and a steel plate welded over the hole. A vertical steel pipe and marker would be welded to the plate. The concrete lined excavation surrounding the hole (called the "cellar") would be pushed in and the location may be graded and revegetated. The marker would remain above ground to provide identification.

Transmission Lines - Any of the electrical transmission lines no longer in use, would be removed.

(2) Restoration of the Surface - Surface restoration would typically be a gradual process, taking place throughout the life of the field and culminating with the final abandonment. Access roads can be ripped up, landscaped and revegetated. Power lines can be landscaped and revegetated. Well and plant locations can similarly be treated but, because of their larger size, complete landscaping to approximate the original surface in steep terrain would not be feasible except in unusual circumstances.

B. Alternatives

1. Withdraw From The Proposed Leasing Areas Acreage Which Has Been Identified in the Analysis of the Proposed Action As Being A Highly Sensitive Area

This alternative would prevent the leasing of areas that have been identified in the Analysis of the Proposed Action as sensitive areas, including, but not limited to: critical wildlife habitat, critical watersheds, areas containing threatened or endangered plants or animals, archaeological sites, outstanding natural areas and buffer zones, when needed.

Areas which are believed to contain potentially valuable archaeological resources, would be withdrawn from leasing until the areas are studied and delineated. Upon reviewing the results of future archaeological studies, a new EAR or updated supplement to this document would be developed in order to provide for geothermal leasing in all or portions of the withdrawn areas.

2. Withhold The Entire Area From Leasing Until Further Resource Information Is Gathered

This alternative would prevent any leasing of lands for geothermal development in the immediate future. There would be no change in the existing environment under this alternative. Therefore, this alternative would not be analyzed further in this EAR.

3. Do Not Lease Any Of The Subject Area

This alternative would prohibit the leasing of any lands in the proposed area. Under this alternative, the existing environment would remain unchanged. Residual impacts would all be indirect. Other sources would have to supply the energy that might have been available from this geothermal area. Potential production of fresh water or mineral by-products also would not materialize. Development of private lands could be even more intensive. Where private lands are adjacent to public lands, geothermal resources of the adjacent public lands could be depleted even though no development took place on the public lands. Surface environmental impacts associated with geothermal exploration and development would not occur if public lands were not leased; but problems associated with potential subsurface effects, such as subsidence, could occur as a result of operations on adjacent private lands. The more intensive development of private land resources could result in less orderly and less efficient overall use of geothermal resources of the area. This alternative would not be analyzed further in this EAR.

C. Background Data

1. Introduction

It has become imperative to explore and develop new sources of energy because of continuous demands for and depletion of low cost fuels used in the production of energy. Geothermal power plant generating costs are, in some cases, lower than the costs of generating power derived from nuclear, coal, or fossil fuels. An increase in activity can be expected for the exploration of the earth's heat energy with advances in sophisticated geothermal exploration techniques. The production of geothermal, electrical power, and its by-products, and the utilization of geothermal resources in space heating, industrial, and agricultural applications could become important industries to the economy of this state because of the many potential fields.

Geothermal energy offers less environmental impact than conventional energy sources. Essentially all of the impact, with the exception of power lines, is confined to a small site. Other power forms have multiple impacts: power dams flood large acreages; coal, oil, gas, and nuclear sources are mined in one place, transported to another place where power is generated and then transmitted via power lines to the areas of use.

The Geothermal Steam Act of 1970 provides for the development of Federally owned geothermal resources. On January 1, 1974, Title 43 of the Code of Federal Regulations (CFR) Group 3200, and Title 30, CFR, Part 270 and 271 became effective. The purpose of these regulations is to implement the Geothermal Steam Act of 1970. Since then, four Geothermal Resource Operations Orders (GRO Orders) have been formulated and passed pursuant to 30 CFR 270.11. Four more GRO Orders are now being prepared.

Geothermal energy development is subject to a wide variety of environmental controls under the authorities of three agencies--Geological Survey, BLM, and U. S. Fish and Wildlife. Such environmental controls are covered in the regulations of these agencies (GS - 30 CFR 270; BLM - 43 CFR 3200) and are part of the exploration notice (Form 3200-9) and lease (Form 3200-21). Additional controls in the form of special stipulations, geothermal resources operational orders (GRO orders), and approved operational plans may also be used. Bonding is required to assure compliance. A "Memorandum of Understanding for the Geothermal Program" outlines the cooperative procedures among the agencies.

Basically, the three agencies consult throughout the leasing program and agree on any needed special stipulations. For all actions up to and including issuance of a lease, the BLM is the responsible agency. For all operational activities undertaken after a lease has been issued, the Geological Survey is the responsible agency.

Opportunities to attach special environmental protection stipulations occur at several points:

> Notice of Intent to Conduct Geothermal Resource Explorations (Form 3200-9) - This form is filed for exploration activities not connected with a lease. The BLM District Manager has 30 days to either approve or disapprove the permit. Special stipulations may be added if needed. The Geological Survey would advise of any recommended stipulations to protect subsurface resource values. A $5,000 compliance bond is required.
>
> Proposed Plan of Operation - Prior to commencing any operation on leased land, the issuance of a lease, the applicant must file a proposed plan detailing his proposed methods for diligent exploration. Environmental protection measures proposed are included. The proposed plan may alert the District Manager to special problems that should be covered by special stipulations. The Geological Survey would also review these plans and may furnish additional comments or information which may be useful for environmental considerations.

However, these plans are filed so early in the process that they would generally be based on little knowledge of the available geothermal resource and, hence, would usually undergo major changes as new exploration data is gathered. They would tend to be written in broad general terms commensurate with the limited data available. Therefore, they cannot be entirely relied upon in anticipating environmental effects.

The chief value of the proposed plan is to commit the applicant to a program of diligent exploration. Reliable environmental judgments can be made later when an actual plan of operation is filed.

Lessees are committed to a variety of environmental controls by regulation, Federal, State and Local law and the standard lease (Form 3200-21) contains protection of the environment and antiquities. Compliance is considered part of the proposed action.

Two bonds are required: a $10,000 bond to insure lease compliance, and a $5,000 bond to indemnify any damages to persons or property. A $150,000 nationwide bond or $50,000 statewide bond may be substituted.

Geothermal Resources Operational Order (GRO Order) - The Geological Survey issues GRO orders for the requirements and procedures followed within a particular region or area. This allows flexibility to address conditions which vary widely from area to area. The BLM District would be consulted by Geological Survey to develop any needed surface resource protection requirements.

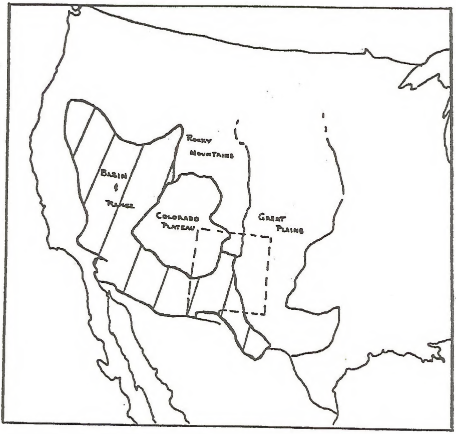
2. Setting of New Mexico Geothermal Fields

A major portion of New Mexico lies within the Basin and Range Province (Map I-3). In New Mexico, the Basin and Range Province is bordered by the Rio Grande Rift and the Great Plains Province in the east, the southern Rocky Mountains in the north, and the Colorado Plateau in the northwest.

Characteristics of the Basin and Range Province are a series of parallel horsts and grabens (displaced fault blocks), recent volcanic activity, high heat flow, and an anomalously thin crust. Geothermal fields are potentially associated with such features. Hot and warm springs and wells are commonly found within the Rio Grande Rift and along the western border faults adjacent to the eastern margin of the Province. Such thermal waters are closely associated with late Cenozoic volcanism and intrusion, and normal faulting within the Basin and Range Province (Figure I-1).

3. Technological Requirements for Geothermal Energy

Usable geothermal energy can best be defined as energy which results from anomalous thermal events (e.g., volcanism, rising of molten magma, etc.). For the production of electricity, the following requirements should be met: reservoir temperatures of at least 356 degrees F (180 degrees C); depths less than 1.9 miles (3 kilometers); fluids



MAP I-3

RELATIONSHIP OF NEW MEXICO TO VARIOUS GEOLOGICAL PROVINCES

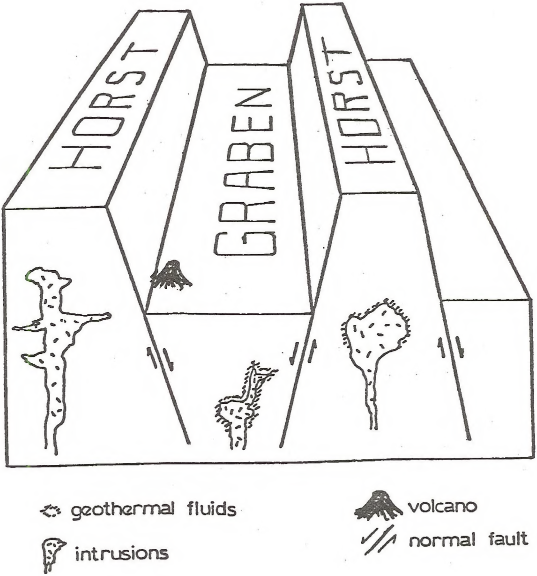


Figure I-1. Relationhip of Horsts and Grabens

for transferring the heat to the surface; an adequate reservoir volume of greater than 3 cubic miles (5 cubic kilometers); sufficient reservoir permeability to insure sustained delivery of fluids to wells at adequate rates (43 CFR 3200.0-5(c)).

Presently, geothermal reservoirs can fall within four general systems; vapor dominated, hot water, hot dry rock, and geo-pressured systems. Of these, only the vapor dominated and hot water systems are presently economically feasible.

a. Vapor Dominated System

This system is dominated by hot gaseous water vapor or steam. Presently, the only commercial geothermal field in the United States is a vapor dominated system located at the Geysers, approximately 80 miles (128 kilometers) north of San Francisco, California. Production first began in 1960 and the field is still undergoing development. Over 100 wells have been drilled and approximately 500 megawatts (mw) of electricity are being produced. One megawatt of electricity supplies the needs of about 1,000 people. Other commercial vapor dominated fields are located at Larderello, Italy, and Matsukawa, Japan.

b. Hot Water System

Present indications are that the hot water system is more common in occurrence than the vapor dominated system. This system involves hot water under pressure. When the pressure is reduced to atmospheric conditions, the hot water flashes (separates) into steam and hot water. After flashing, the steam is used to drive turbines and the hot water is disposed of by re-injection, evaporation, or discharge into nearby waterways. Corrosion, scaling, and disposal of large volumes of water and associated minerals are problems usually associated with this system. Technological advancements in the future would no doubt result in a much more efficient use of the hot water system.

Many nations throughout the world are developing hot water systems. One system within the U.S. is the Valles Caldera Field (Baca Ranch Location) in north central New Mexico. Other nations which are developing hot water systems are: New Zealand, Japan, Iceland, Mexico, and the Soviet Union.

4. Geothermal Lease Status in New Mexico

Leases for geothermal development are currently being granted on Federal, State, and private lands within New Mexico. At present, the U. S. Geological Survey (USGS) has designated eight Known Geothermal Resource Areas (KGRA) (43 CFR 3200.0-5(k)). These areas consist of: Baca No. 1, Gila Hot Springs, Kilbourne Hole, Kilbourne Hole Addition, Lower Frisco Hot Springs, San Ysidro, Radium Springs, Lightning Dock, and Socorro Peak. Each KGRA may or may not contain Federal, State, and private lands.

Baca No. 1 and Socorro Peak were designated by the USGS as KGRAs because of geologic evidence. The other areas were designated KGRAs because of competitive interest as defined by the filing of applications which overlapped one another by one-half or more (43 CFR 3200.0-5(k)(3)).

Industry has become very interested in geothermal resources on Federal land. On May 15, 1975, twelve tracts of Federal land in the Kilbourne Hole KGRA became available for competitive bidding, nine tracts received bids and leases were issued. In June 1975, 47 non-competitive geothermal leases were issued outside, but adjacent to, the Kilbourne Hole KGRA. Industry has also become interested in the Lightning Dock KGRA. As of November 1976, the BLM has issued 64 geothermal leases covering 136,558 acres (55,265 hectares). In December 1976, 17 lease applications were received for land in the proposed Socorro Peak Geothermal leasing area for about 40,000 acres (16,000 hectares).

The State of New Mexico also issued geothermal leases. In August 1974 and March 1975, the State conducted geothermal lease sales; however, bids were received only for lands within or near indicated thermal anomalies, and these lands were subsequently leased.

The Federal government does not keep records concerning the leasing of private lands. Many land owners are refraining from leasing to see what develops in regard to geothermal resources adjacent to their private lands.

5. Economic Analysis

a. Energy Consideration

Present and anticipated demand for the end product of geothermal energy, whether it be electrical energy or heat energy as applied to greenhouse or other industrial uses, is virtually unlimited. The electrical energy aspect is better known, and would, therefore, be the principal focus of this analysis. Demand, assuming costs are competitive, is evidenced by the recent construction of the giant coal-fired electrical power generating plants in the Farmington, New Mexico area, and the huge nuclear plants near El Paso, Texas; Belen, New Mexico; and Greenlee, Arizona, on which construction is expected to be substantially completed within the next 20 years. The demand for non-petroleum generated sources of electricity has been greatly accelerated by the national petroleum and natural gas shortage. U. S. energy demand is expected to continue increasing at a rate of 3 to 5 percent per year. To keep pace, more fuel would have to be imported (imports are currently about 4 percent) or develop more domestic sources. Former President Nixon stated that the U.S. policy goal is to become independent in energy resources by 1980.

All forms of energy supplement one another in the total energy picture. Should geothermal energy be used to produce electricity, other forms of energy (coal, oil, gas) would be freed for use elsewhere.

Estimates of our geothermal potential vary widely but suggest that by the year 2000 such energy may supply 5 to 14 percent of U.S. use. This is a significant amount considering that hydroelectric power currently supplies only about 5 percent of the total.

In the short range, it appears that geothermal sources stand a far better likelihood of substantial contributions to the energy pool than do such exotic sources as sclar energy, breeder and fusion reactors, fuel cells, etc.

b. Geographic Distribution of Demand

The geographic distribution of demand is expected to be from the southwestern states, especially southern California, Arizona, New Mexico, and Texas.

c. Economic Feasibility of Extraction

The economic feasibility of extraction would be an unknown factor until extensive exploration drilling and testing has occurred.

d. Alternate Sources

Alternate sources of electrical energy are from coal, petroleum, natural gas, nuclear energy, solar energy, and wind. Comparative costs, advantages, and disadvantages of the alternatives are beyond the scope of this analysis.

e. Transportation Network

A transmission network for the electric power generated from the geothermal resource would have to be built to the electrical substation in the city of Socorro with its associated transmission lines.

f. Economic Considerations

There are several ways to view the economic implications of geothermal development: direct revenues, indirect revenues, direct expenditures, and indirect expenditures.

Direct Revenues - Lease rentals and royalties are distributed as follows: 82.5 percent - U. S. Government, and 17.5 percent - State Governments.

Rentals - Each lease brings in $1/acre per year annual rental (minimum) which increases on a graduated basis after the fifth year. Advance rentals filed during the first 3 months of filing in Nevada total 1.7 million dollars.

Royalties - When production is reached, royalties of 10 to 15 percent of the value of the steam are assessed. Royalties up to 5 percent are also paid on by-product minerals, including commercial demineralized water.

Bonus Bids - On competitive lease sales, bonus bids are an additional source of revenue. In the first Federal lease sale held in California on January 22, 1974, twenty leasing units were bid on with 57 bids totalling $12,500,000. The highest bid for a single leasing unit was $3,200,000, which amounts to $1,367.50 per acres for the 2,340 acre unit.

Indirect Revenues - Taxation by State and local subdivisions accounts for an additional increment of revenue. Taxes paid to Sonoma Co. from the Geysers approximate $1 million per year for the current 400 mw capacity.

Dr. Robert W. Rex, President of Republic Geothermal Inc., in remarks to the Sub-Committee on Energy, Committee on Science and Astronautics, U. S. House of Representatives, on September 18, 1973, said in part"...Every 1,000 megawatts of geothermal development on Federal lands yield about $1 billion of public revenue; 73 percent to the Federal government, 11 percent to State governments which have income taxes...and 18 percent to County governments.

Direct Expenditures - Development of a 110 mw plant costs 15 to 17.5 million dollars at the Geysers. Individual wells cost about $150,000 to $200,000 each.

Indirect Expenditures - The local business community would be affected by geothermal development, both by increased business and by having to provide additional services.

During exploration drilling, two drilling rigs might be used for 1 to 2 years. Employees would consist of about 40 people directly involved in drilling with 10 to 20 additional service people intermittently involved.

Development would advance in 55 to 110 mw increments in an orderly fashion over a period of 2 to 10 years. Drill crews for 2 to 3 rigs would number 40 to 60, and 20 to 30 additional people would be involved in plant construction. All of the above personnel would be temporary.

Once the field is fully operational, five (5) permanent employees are needed for field production plus five (5) more for each 110 mw plant. One drilling rig would be needed full time, adding 20 more permanent employees to the area.

Thus, for several years, a local community would be burdened with providing necessary school and service facilities for between 40 and 90 additional temporary families. Thereafter, 30 or more families would become permanent residents, also requiring services.

In the short run, communities near a geothermal development would be financially strained. However, such development is capital intensive and in a few years the increased tax base should be much greater than community expenditure on a per capita basis of additional residents.

II. DESCRIPTION OF THE EXISTING ENVIRONMENT

A. Air

The quality of the air in the area is generally good. Periodically, there are local air pollution problems.

The Environmental Improvement Agency (EIA) of New Mexico supervises the sanitary landfill operations near Socorro, San Antonio, Lemitar, Veguita, and Magdalena. These operations have been effective in controlling air pollution due to burning. Burning permits must be obtained from EIA to burn limited areas of range and agricultural land.

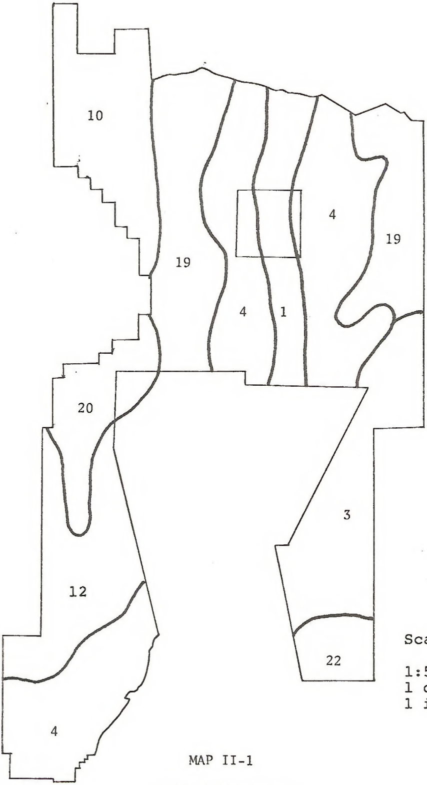
In the relatively high velocity spring winds, fugitive dust can be a problem. Gravel roads, ditch banks, and/or yards as well as rangelands may be a source of wind-carried dust.

Recorded temperatures, since 1859, range from -31 degrees F (-35 degrees C) to 113 degrees F (45 degrees C). The freeze-free period in the valleys is 6.5 months. At higher elevations, this period is reduced to 4 months. Winds in the valleys are predominantly northerly in the winter and southerly in the summer. Southerly winds are frequent in the afternoon, while northerly winds are common in the mornings. On mesas and in mountains, prevailing winds are more westerly. Winds blow at 12 miles per hour (19 kilometers per hour) or more in the spring. During the remainder of the season, they average 8 miles per hour (13 kilometers per hour) or less. Evaporation, as officially measured, ranges from 105 inches (267 centimeters) per year in the valleys to 95 inches (241 centimeters) at higher elevations.

B. Soils

Within two years, a modern third order soil survey will have been completed. The soil resource is described below. These associations and their physiographic units are shown in Map II-1 and Table II-1. The soil characteristics and qualities are shown in Table II-2.

Gila-Vinton-Glendale Association (1) - Included in this association are nearly level to gently sloping soils occurring on the flood plain and alluvial fans adjacent to the



Scale

1:500,000
1 cm = 5 km
1 in. = approx. 8 mi.

MAP II-1

SOIL ASSOCIATIONS

TABLE II-1

SOILS OF PHYSIOGRAPHIC UNITS IN SOCORRO PEAK GEOTHERMAL LEASING AREA

Physiographic Units	Associations	Map Ref. Number
Valley	Gila-Vinton-Glendale	1
Valley Slopes	Berino-Bluepoint-Onite	3
Piedmont Slopes	Nickel-Canutio-Rough-Broken Land	4
Undulating Steep Landscapes	Harvey-Witt-Pinon	10
Alluvial Fans	Millett-Sedillo	12
Steep Hilly Mountains	Rockland-Tehmans-Lozier	19
Mountains	Rockland-Chimayo-Luzena	20
Broken Mountains	Lava Rockland-Graham	22

TABLE II-2 (Sheet 1 of 3)

SOIL ASSOCIATION CHARACTERISTICS

Association	Series	*Restrictive Depth	Drainage	Runoff	*Depth To Water Table
1	Gila	Deep	Favorable	V. Slow	> 6.0
	Vinton	Deep	Poor	V. Slow	2-3
	Glendale	> 6.0	Floods	V. Slow	> 6.0
3	Berino	V. Deep	Good	Slow	> 6.0
	Bluepoint	Deep	Good	Slow	> 5.0
	Onite	V. Deep	Good	Slow	> 6.0
4	Nickel	V. Deep	Good	Slow	> 6.0
	Camitio	Deep	Good	Slow	> 6.0
	Rough Broken Ld.				
10	Harvey	Deep	Good	Moderate	> 6.0
	Witt	Deep	Favorable	Moderate	> 6.0
	Pinon	Shallow	Good	High	> 6.0
12	Millett	Deep	Good	Moderate	> 6.0
	Sedillo	Deep	Good	Moderate	> 6.0
19	Rock Ld.				
	Lehmans	Shallow	Good	Medium	> 6.0
	Lazier	Very Deep	Good	Slow	> 6.0
20	Rock Ld.				
	Chimayo	Shallow	Good	Rapid	> 6.0
	Luzena	Shallow	Good	Rapid	> 6.0
22	Lava Rock Ld.				
	Graham	Moderately Deep	Good	High	> 6.0
		3	4	5	6

*In feet

TABLE II-2 (Sheet 2 of 3)

SOIL ASSOCIATION CHARACTERISTICS

Association	Embankment	Top Soil	Shallow Excavation	Roads	Road Fill	Reservoir Limitation
1	Piping	Good	Slight	Low Strength	Fair	
	Seepage	Poor	Severe	Severe	Fair	Seepage
	Low Strength	Poor	Slight	Severe	Poor	Favorable
3	Low Strength	Fair	Slight	Moderate	Fair	Seepage
	Piping	Poor	Moderate	Moderate	Good	Seepage
	Piping	Good-Fair	Slight	Slight	Good	Seepage
4	Piping	Poor	Severe	Severe	Moderate	Poor
	Piping	Poor	Severe	Severe	Poor	Seepage
10	Piping	Poor	Slight	Moderate	Fair	Seepage
	Low Strength	Fair	Moderate	Moderate	Fair	Favorable
	Rock Outcrop	Poor	Severe	Severe	Poor	Poor
12	Piping	Poor	Severe	Moderate	Good-Fair	Poor Seepage
	Piping	Poor	Moderate	Moderate	Good	Seepage
19						
	Piping	Poor	Severe	Severe	Poor	Severe
	Low Strength	Poor	Moderate	Poor	Poor	Severe
20						
	Low Strength	Poor	Severe	Poor	Poor	Severe
	Low Strength	Poor	Severe	Severe	Poor	Poor
22						
	Low Strength	Poor	Severe	Severe	Poor	Severe
	7	8	9	10	11	12

TABLE II-2 (Sheet 3 of 3)

SOIL ASSOCIATION CHARACTERISTICS

LEGEND

Column 3. Restrictive Depth

Very Deep	76"	Shallow	10" to 20"
Deep	36" to 60"	Very Shallow	10"
Moderately Deep	20" to 36"		

Column 7. Embankment - degree of success the embankment for holding water. "Seepage" - slow leaking. "Piping" - rapid flow - through embankment. "Low Strength" - embankment could easily collapse.

Columns 9 and 10. Shallow Excavation and Roads - indicates potential collapse hazard.

Column 11. Road Fill - may be good, moderate, fair, or poor.

Column 12. Reservoir Limitation - in terms of construction limitations.

Rio Grande. The soils, which are dominantly deep and highly stratified, are forming an alluvium of mixed origin. The texture of the surface layers varies from sand to clay; but the commoner textures are moderately coarse, medium, and moderately fine. Although the soils, in general, are adequately to moderately well drained, some are poorly drained and saline. The poorly drained soils occur throughout the association, but they are more common in the southern part of the county below the village of San Antonio. They commonly occupy low positions on the landscape or are near the river channel, where they are subject to seepage from the Rio Grande. It is extremely difficult to keep the water tables below the root zone in many of these poorly drained soils during the growing season because of their low position and inadequate drainage outlets.

Although many soils have properties suitable for engineering installations in this association, it includes areas of wet and saline-alkali soils as well as soils with moderate to high shrink-swell potential and low bearing capacities that would need to be considered in construction. Localized areas of these soils also need protection from flooding by runoff from adjacent higher lying lands. Because of their flat topographic position and relatively high moisture, wind and water erosion is not a problem on these soils.

Berino-Bluepoint-Onite Association (3) - This association occurs east of the Rio Grande. It includes a part of the Jornada del Muerto closed basin that lies within the proposed area. A few nearly level depressional areas are included in the association, but it characteristically occurs on gently sloping and undulating landscapes. Coppice dunes forming in and around mesquite and other shrubs are common in the wind-eroded areas. The soils in this association, which are generally moderately deep to deep, are developing in eolian and old valley-filling sediments derived from a wide variety of rocks. Because they are sandy, these soils are moderately affected by wind erosion and only slightly influenced by water erosion.

Nickel-Canutio-Rough Broken Land Association (4) - This association is adjacent to the flood plain of the Rio Grande. It consists of gently sloping to steep alluvial fans, terraces, and valley-filling slopes that are dissected by numerous drainageways. Although much of this unit is dominated by rough broken landscapes, it includes some long ridges with relatively smooth and gently sloping surfaces. Ridge tops are gently sloping and vary from about 100 feet (30 meters) to one-half mile (0.8 kilometers) or more in width. The sides of the ridges are usually steep, but slopes may range from 5 percent to as much as 45 percent. Small areas of gently sloping fans and terraces also occur in the lower part of this association near the Rio Grande flood plain. The soils, which are often gravelly are forming in coarse-textured alluvial fan sediments of mixed origin.

The steeper portions of this association are subject to severe water erosion. Flatter areas suffer only moderate wind and water erosion.

Millet-Sedillo Association (12) - This association is dominated by gently to strongly sloping and undulating alluvial fans and valley-filling slopes that are located generally at the base of mountain ranges. Slope gradients are usually less than 5 percent, but they may range up to 15 percent near the base of mountains in areas occupied by the millet soils. Small areas of strongly sloping to moderately steep soils also occur adjacent to drainageways. The soils, which are characterized by their gravelly textures or gravel content, are developing in old valley-fill sediments of mixed origin. Because of the coarse texture of the surface, this soil association is subject to only very slight wind and water erosion.

Harvey-Witt-Pinon Association (10) - This association occurs mainly on gently to strongly sloping upland plains and valleys interspersed with moderately steep and rolling upland ridges and hills. There are also included a few steep escarpments or breaks and nearly level to gently sloping valley bottoms. The moderately steep and rolling uplands and breaks areas are more extensive in the eastern part of this association near Lincoln County. The soils range in depth from shallow on the upland ridges and low hills to moderately deep, and deep on the less sloping areas. These areas are subject to moderate or severe water erosion and no wind erosion.

Rock Land-Lehmans-Lozier Association (19) - Included in this association are desert mountain ranges, isolated mountain peaks, and hills. Characteristic features of this unit are the steep to very steep slopes and shallow and rocky soils with numerous exposures of bedrock. A wide variety of bedrock types is included, with andesite, rhyolite, limestone, and sandstone being dominant. There is no wind erosion. There is moderate water erosion between bedrock.

Rock Land-Chimayo-Luzena Association (20) - This association includes areas of hilly to very steep mountain foothills and intermediate mountain areas. Although there is a relatively wide range in altitude, most of this association ranges between 6,000 feet (1,830 meters) and 7,500 feet (2,290 meters) in elevation. The topography is variable and ranges from gently to strongly sloping and rolling ridge tops to steep and extremely steep mountainside slopes. Small and narrow floors below the steep mountainside slopes and canyon walls are gently to strongly sloping.

The soils, which are, generally, stony or gravelly and shallow, are forming dominantly in materials weathered from a wide variety of igneous rocks. Rock outcrops and some rock slides are common on the steep side slopes below upland ridges. There is no wind erosion. There is moderate water erosion between bedrock.

Lava Rock Land-Graham Association (22) - This association is found in the southeast leg of the proposed area. Included are soils forming in materials of volcanic or basic igneous origin on lava flows. A distinctive feature is the stony soils and associated outcrops of basalt rock. These outcrops of basalt rock and associated stoniness provide a rock mantle over much of the land surface. Although there are included small areas or pockets of moderately deep and deep soils, the soils of this association are dominantly shallow and stony. The land surface on the mesa tops and lava flows is usually gently to strongly sloping, but may range from nearly level to moderately steep. The sides and fronts of the lava flows are steep to very steep. No wind or water erosion is taking place.

C. Geology

1. The Rio Grande Rift (After Sandford et al, 1976)

The Socorro Peak Geothermal Resource Area is located within the Rio Grande Rift, a major structure formed by crustal extension beginning about 29 million years (MY) ago and continuing to the present. North of Socorro the rift consists of a series of linked structural depressions with raised margins that extend into central Colorado. In southern Colorado and northern New Mexico, the rift penetrates the southern Rocky Mountains. In central New Mexico, the rift lies between the Colorado Plateau and the High Plains. South of Socorro, the rift merges in a complex and unknown way with the Basin and Range Province.

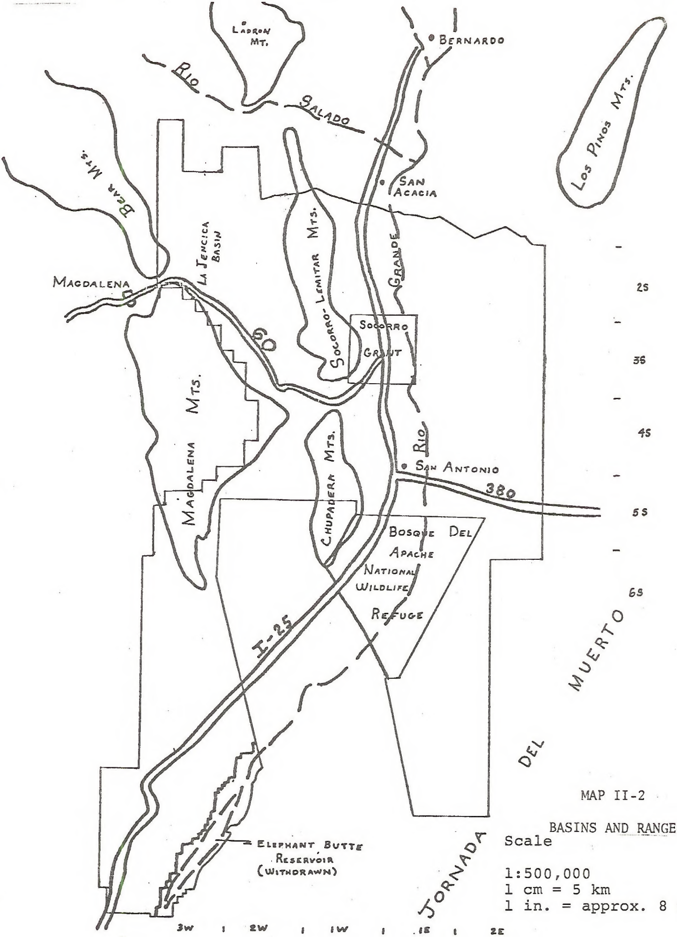
In the Socorro Peak Geothermal Area, the rift consists of a series of basins and ranges (Map II-2). The central ranges, the Socorro-Lemitar, and Chupadera Mountains which separate the La Jencia Basin from the Socorro Basin, are intragraben horsts that formed relatively late in the history of the rift, less than 9 MY ago. Development of prominent intragraben horsts through several thousand feet of Cenozoic sedimentary fill is known to occur at only two locations along the rift, near Socorro and Las Cruces.

A gravity survey of the rift in the vicinity of Socorro indicates that the long narrow Socorro Basin is composed of three linked structural depressions. The two depressions adjacent to the Socorro-Lemitar Mountains are highly asymmetrical. Narrow fault zones with large displacements, perhaps as great as 1.9 miles (3 kilometers) border the western margins of these downdropped crustal blocks. From their deepest points west of the Rio Grande, these structural basins rise fairly gradually to the east, probably by a combination of step-faulting and tilting. The La Jencia Basin is not as narrow as the Socorro Basin nor as structurally asymmetrical. However, the total structural relief for the La Jencia Basin is comparable to that of the structural depressions comprising the Socorro Basin, i.e., on the order of 1.9 mile (3 kilometers).

A great deal of volcanic activity has accompanied the formation of the Rio Grande Rift. The periods of greatest activity were from 20 to 26 MY ago and from 5 MY ago to the present. Basaltic andesites were most abundant during the first period of volcanism, whereas, true basalts dominate the latest period. Basalt flows, of a very recent age, occur in the Socorro area.

Numerous thermal springs occur along the entire western margin of the rift. Coincident with these springs is a ribbon of high heat flow, greater than 2.5 heat flow units (HFU). In the Socorro area, the largest and hottest thermal springs are located in the southern end of Socorro-Lemitar Mountains which is also an area of very high heat flow, as much as 10 HFU.

Geophysical observations, made over a period of years, indicate the existence of magma at intermediate depths in the crust beneath the Rio Grande rift in the vicinity of Socorro, New Mexico (Map II-3). Important geophysical characteristics of the region are a diffuse



MAP II-2

BASINS AND RANGES

Scale

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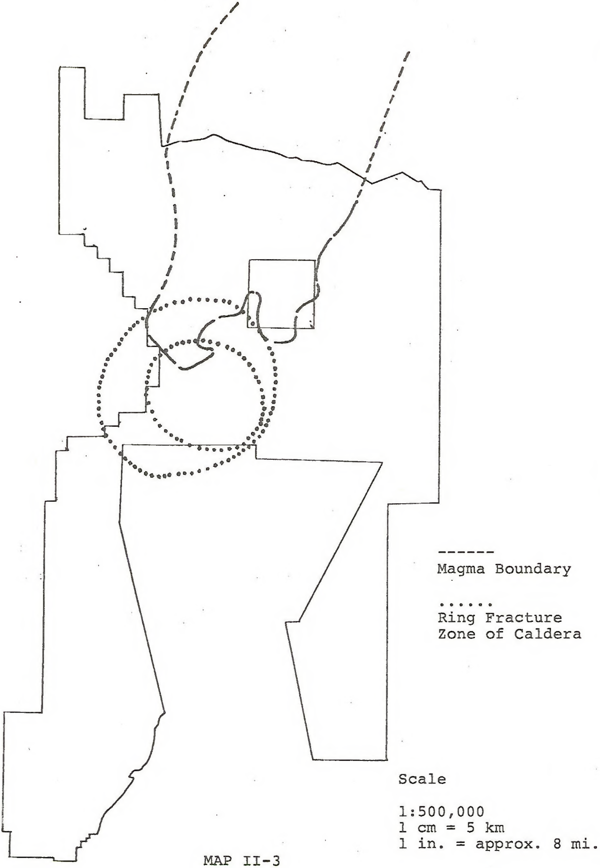
1 cm = 5 km
1 in. = approx. 8 mi.



MAP II-3

APPROXIMATE LOCATION OF MAGMA BODY AND CALDERA geographical pattern of seismic activity, earthquake swarms, exception-ally strong seismic reflections from depths of 11.2 to 13 miles (18 to 21 kilometers), high heat flow, and historical surface uplift. The rift at Socorro also has some unusual geologic features such as intragraben horsts. Each of the geophysical and geologic observations can be explained in a number of ways, but taken collectively, they make a strong case for the existence of a rather extensive layer, 386 square miles (1,000 square kilometers), of magma in the crust along the axial region of the rift. The possibility exists for smaller magma bodies at depths of less than 8 miles (13 kilometers).

2. The Socorro Caldera (After Chapin and Chamberlin 1976)

Socorro is located on the northeast rim of a volcanic caldera about 26 MY old (Map II-3). This Caldera is situated at the northeastern end of a series of overlapping calderas in the San Mateo and Magdalena Ranges. Manganese prospects and mines are found along the margins of the Socorro Caldera. The southern part of the area is unmapped and the relationship between units is poorly known.

Northwest of Socorro is Polvadera Mountain, in the Lemitar Range. It is a west-dipping hogback, composed of dark-colored Oligocene ash-flow tuffs and andesite flows, above light-gray Pennsylvanian limestones and reddish Precambrian rocks. These rocks are truncated on the northeast corner of Socorro Peak ("M" Mountain) by the ring-fracture zone of the Socorro Caldera. Most of the rocks forming the escarpment south of this point are moat deposits. Precambrian and Paleozoic rocks do not crop out again in the Chupadera Range until southwest of San Antonio (about 16 miles, 26 kilometers). Early moat deposits are local ash-flow tuffs, andesitic to latitic flows, rhyolitic domes and flows, and associated air-fall tuffs. North of Blue Canyon are reddish domal flows, underlain by greenish-white air-fall tuffs.

Late Miocene (10 to 12 MY old) silicic domes and flows cap Socorro Peak and overlap the northern caldera margin. The domal flows rest upon reddish fanglomerates and playa deposits similar to those in the Popotosa Formation (basal Santa Fe Group) but, in this area, the early basin-fill sediments are controlled by caldera topography. A massive, dark-colored cliff on the east side of Socorro Peak is composed of west-dipping fanglomerates belonging to the late caldera fill. Mine dumps of the Socorro Peak silver district are present along the base of the escarpment; the veins are in down faulted late-Miocene silicic flows equivalent to those which cap the Peak. Numerous north-tending faults along the lower part of the escarpment offset the caldera margin.

South of Blue Canyon, conspicuous reddish knobs and cliffs are silicic domes and flows of the caldera moat. Some may be superimposed intrusives of late Miocene age. The Grefco perlite deposit is a silicic dome on which discordant potassium-argon dates of 23.7 and 33.2 MY have been obtained. The 23.7 MY date may be close to the actual age. Late Pliocene basalt flows cap mesas on both sides of the Grefco mine and unconformably overlie many faults and older moat deposits. Light-colored friable sands of the ancestral Rio Grande are exposed in road cuts leading to the water tank on top of the mesa and also along the base of the mesa left of the tank.

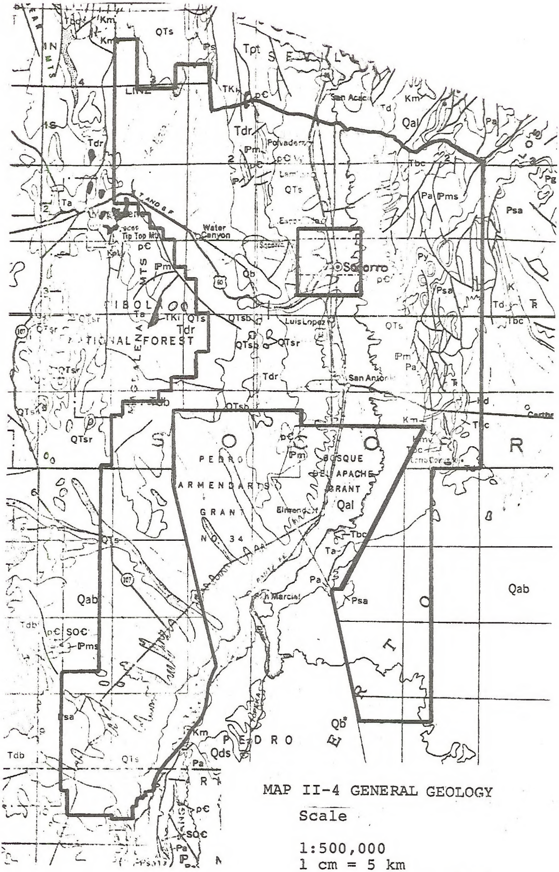
3. General Geology

Map II-4 shows the general geology of the area. Field work and mapping is being done in the area by faculty and students of New Mexico Institute of Mining and Technology.

D. Water (See Appendix C)

Hydrologic Cycle - Precipitation in the form of rain and snow are the major sources of water in the Socorro Peak Geothermal Area. Precipitation ranges from 8 to 18 inches (20 to 46 centimeters). Seventy percent of the annual average precipitation is from July through September. Figure II-1 shows this distribution of precipitation by months. This distribution is because of moisture-laden air masses moving in from the Gulf of Mexico during July, August, and September. Winters have little or no rain. Surface water runoff, during intense summer thunderstorms, is a major source of uncontrolled water. Very light rains may not cause surface runoff. They may not penetrate the soil to any extent. This water is frequently held on surface vegetation or near the surface and evaporated or transpired back to the atmosphere.

Once water has entered the soil, it is either held by capillarity, removed by plant roots, or seeps to the groundwater table. The water table furnishes water for wells, springs, and permanent stream flow. The quantity and



MAP II-4 GENERAL GEOLOGY

Scale

1:500,000
1 cm = 5 km
1 in. = approx. 8 mi.

MAP II-4 LEGEND

GENERAL GEOLOGY

AGE	SYMBOL	STRATIGRAPHIC UNIT OR DESCRIPTION
Quaternary	Qal	Alluvium-mainly in flood plain of Rio Grande
	Ql	Landslides and mudflows
	Qs	Spring deposits
	Qb	Basalt flows, location of volcanic vents indicated by asterisks
Quaternary (?) and Tertiary	QTs	Santa Fe group, undivided, includes some basalt flows
	QTp	Pediment, terrace, and other deposits of gravel, sand, and caliche
Tertiary	Tb	Andesites and basaltic andesite flows, breccia, and tuffs
	Tbc	Baca formation
	Tki	Intrusive rocks
	Td	Datil formation, undivided volcanic, (a, b, c, l, r, s, y) are facies
Cretaceous	Kmv	Mesaverde group, undivided
	Kcc	Crevasse canyon formation, (part of Kmv)
	Kg	Gallup sandstone, (part of Kmv)
	Km	Mancos shale
	Kd	Dakota sandstone
Triassic	T̄R	Triassic rocks, undivided
Permian	Psa	San Andres limestone
	Pg	Glorieta sandstone
	Py	Yeso formation
	Pa	Abo sandstone
Pennsylvanian	ℙm	Madera formation
	ℙs	Sandia formation
Mississippian	M	Mississippian rocks, undivided
Precambrian	p€	Granite, schist, gneiss, and quartzite, undivided

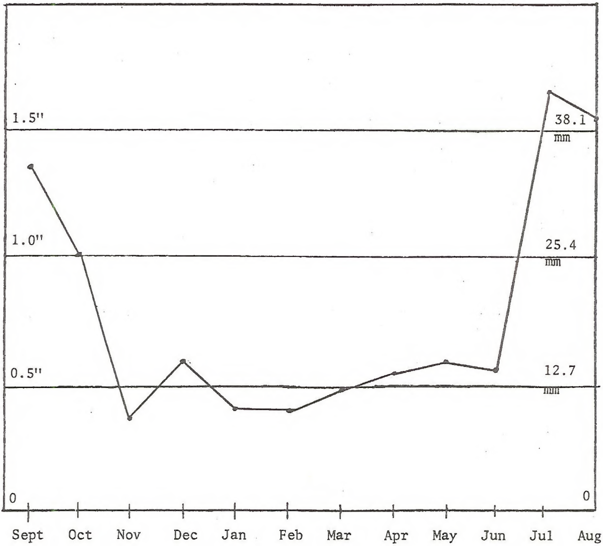


Figure II-1. Average Monthly Precipitation in Socorro, New Mexico (74-Year Average Ending in 1960)

quality of this groundwater is extremely important in a semi-arid climate. It regulates many aspects of the environment such as livestock management and water use.

The most important surface water, in the area, is the southward-flowing Rio Grande. This major river approximately bisects the area. All arroyos east and west of the Rio Grande drain into it directly. None have perennial flow. The area to the north is drained by the larger Rio Salado; and it is an intermittent stream. Nogal Canyon, Six Mile Canyon, Blue Canyon, and San Lorenzo Arroyo, all drain eastward into the Rio Grande. The Arroyo de la Parida, Arroyo de los Pinos, Arroyo de la Presilla, and the Arroyo de las Canas are all located on the east side of the Rio Grande and flow westward into this major river. All of these small basins flow only intermittently. Intensive, short duration, widely scattered summer thunderstorms lead to differential runoff and erosion from these small basins.

The Rio Grande above Bernardo, flows at an annual rate of about 33 acre feet (4.07 hectare-meters) per square mile (2.6 square kilometers) (Table II-3). The Rio Salado, which flows only after rather widely distributed heavy rains, produces less than 2 acre feet (.246 hectare-meters) of runoff per square mile. Peak flows are not so greatly different when expressed on a per square mile (square kilometer) basis. The Rio Grande basin has a peak flow of approximately one cubic foot per second (cfs) (0.03 cubic meters per second); the Rio Salado, 0.33 cfs (0.01 cubic meters per second); and La Jencia Creek approximately 2 cfs (0.06 cubic meters per second) per square mile. Apparently small drainage areas, centered in an intense rain area for any given storm, make for high peak discharges.

The water resources data for New Mexico do not show water quality for very small drainage basins. Table II-4 shows average acre feet of sediment delivered per square mile by the Rio Grande at Bernardo; the number of times recommended limits have been exceeded for total dissolved solids (TDS), sulfate, and chloride. Similar data are shown for Rio Salado. Mean monthly fecal coliform counts are available for the Rio Grande at Isleta Pueblo. They range from 260 per 100 cubic centimeters in February of 1974, to 8,613 in July of that year. These values are generally in excess of the standard.

Toxic substances such as heavy metals have not been studied extensively. Preliminary data shows boron and

TABLE II-3

SURFACE WATER FLOW FROM STREAMS IN SOCORRO PEAK GEOTHERMAL AREA

Stream	Drainage Area Sq. Miles	Total AC Feet of Flow Annual X 10^3	Peak Flows Per Sq. Mile CFS
Rio Grande at Bernardo	19,230	630.3	1.10
Rio Salado	1,380	2.298	0.33
La Jencia Creek	195	-	2.25

Data taken from--March 1976 Middle Rio Grande Basin Plan, New Mexico Water Quality Control Commission, and from, Anonymous Water Resources Data for New Mexico--Report 1974.

TABLE II-4

POLLUTION OF SURFACE WATERS

Middle Rio Grande Basin Plan*

Stream	Average Acre Feet Sediment Per. Sq. Mi.	TDS[1] mg/l 1500	Sulfate[1] mg/l 500	Chloride[1] mg/l 250
Rio Grande at Bernardo	0.08	0(146)	1(219)	0(219)
Rio Salado	0.61	4(33)	10(51)	4(53)

[1] Heading on Column gives proposed National Academy of Science standard. Number in ( ) is number of samples taken. Exterior number is number of times National Academy of Science Standard exceeded.

*Data from Water Quality Control Commission
1975 Water Quality in New Mexico.
Unpublished Bureau of Reclamation -
Interstate Stream Commission data.

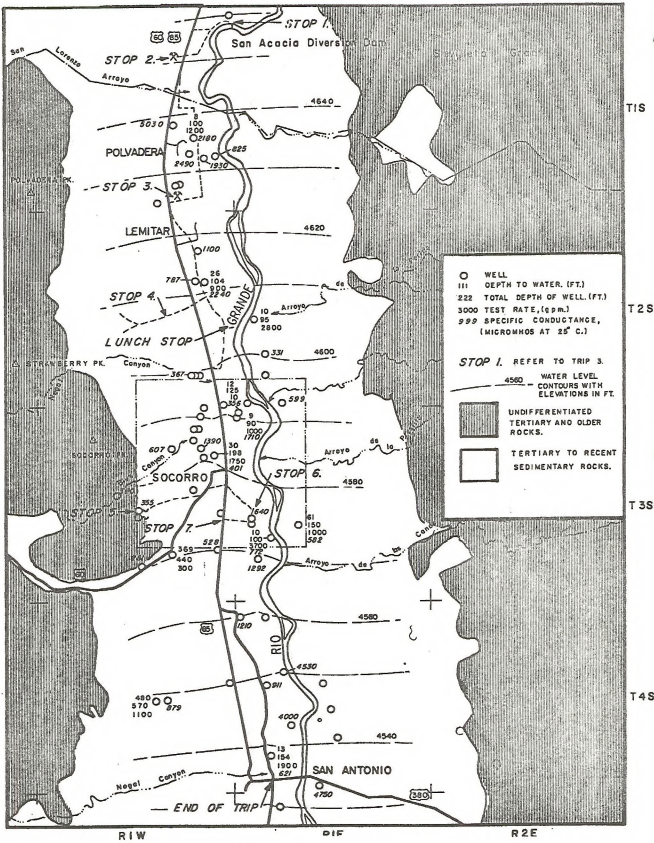
selenium levels above the limits recommended by the National Academy of Sciences (0.5 mg/l for livestock watering and 0.75 mg/l for irrigation for boron, and 0.01 mg/l for livestock watering for selenium) in the Rio Grande.

Sedillo Springs in the city of Socorro, and a well in Magdalena have been tested, indicating mercury levels which exceed proposed primary drinking water standards. Other wells in Magdalena exceed the standards for barium and selenium.

Groundwater within the Socorro Peak Geothermal Area has been discussed in a number of publications. The New Mexico State Engineer's Office has defined the Rio Grande Underground Water Basin. This basin, as defined, includes all of the proposed geothermal area. The present flood plain of the Rio Grande is the largest county storage reservoir for groundwater. This Socorro Valley section of the river is shown in Map II-5. The Tertiary to Recent sedimentary rocks in the flood plain are thought to be at least 600 feet (183 meters) deep. They are six miles (9.7 kilometers) wide on the average. Assuming the necessary storage coefficients, the groundwater storage would represent almost 4 million acre feet (493,000 hectare-meters). This would be enough water to cover Socorro County 1 foot (0.3 meters) deep.

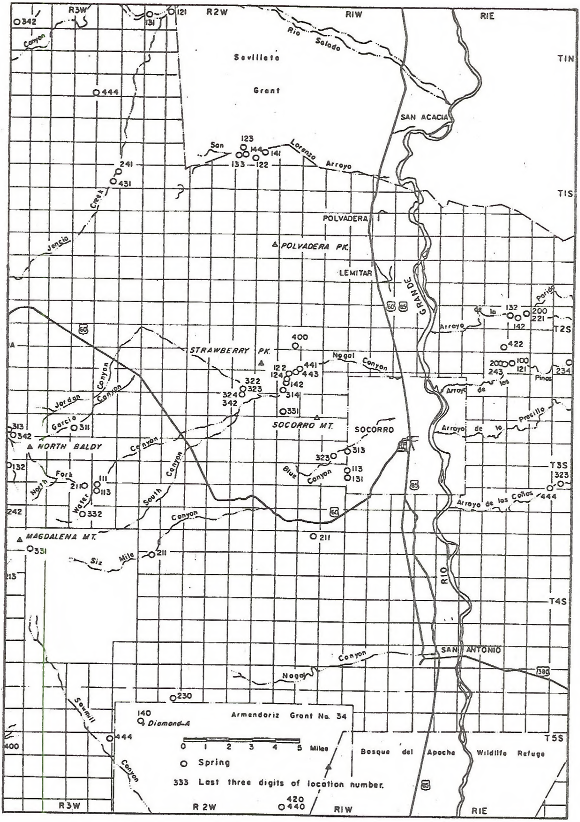
Other more local supplies of groundwater in the form of springs have also been reported. These spring water supplies are of equal importance to the relatively large quantity of groundwater found immediately adjacent to the main channel of the Rio Grande. The city of Socorro uses two springs, supplemented by two wells, for its municipal water system. Wells and springs supply other small villages. There are an estimated 65 irrigation wells in the proposed geothermal area. Most of these wells are located in the valley floor along the Rio Grande. They range in capacity from 300 gallons per minute (gpm) (135.5 liters per minute) to 2,500 gpm (9,462.5 liters per minute). The location of springs is shown in Map II-6.

The movement of groundwater in the valley floor adjacent to the Rio Grande channel has been estimated to be 27 acre-feet (3.33 hectare-meters) per day. The level of the water table in this area is generally 6 to 8 feet (1.8 to 2.4 meters) below the surface. The gradient of this water surface from north to south, as seen from the water contours in Map II-5, is four and one-half feet per mile (0.85 meters per kilometer).



MAP II-5

SELECTED WELL DATA AND WATER TABLE CONTOURS



MAP II-6

SPRING LOCATIONS

Groundwater supplying the springs and wells is generally found at a much greater depth than that in the valley floor. This water tends to move downslope from the higher elevations. It accumulates in the bottoms of the arroyos. This water supply is in no small part dependent upon local rainfall and infiltration of water into the soil surface.

Total dissolved solids (TDS) are a good indication of groundwater pollution by salts. The State of New Mexico recommends that the TDS monthly average concentration shall not exceed 1500 mg/l for water in the Rio Grande at San Marcial, New Mexico. As irrigation of an agricultural area continues, TDS of the groundwater usually increase.

The springs east of the Rio Grande are characterized by high sulfate content and relatively high TDS with the exception of Ojo del Rancho de Lopez (2S.2E.20.234). Most of the springs are calcium sulfate waters. Some of the springs, particularly in the vicinity of Ojo de la Parida and at Ojo de las Canas, are in equilibrium with the system calcium carbonate-carbon dioxide-calcium sulfate-water. A few of the springs that are not in equilibrium are still fairly close. This equilibrium relationship is to be expected as the water-bearing formations contain both limestone and gypsum. Although some of the units may contain halite or similar evaporites, this is not reflected in the analyses. In fact, low chloride both in percentage and absolute amounts is a constant characteristic of these waters, with only one sample having more than 40 ppm.

The springs west of the Rio Grande show a much greater diversity than do those to the east. The springs west of the Rio Grande do have some features in common, since with one exception they are low in chloride, and generally, are low in sulfate. They tend to be of either a calcium bicarbonate or a sodium bicarbonate type. The yields of the springs are rather low; the highest coming from fault line springs.

The water in the spring in the "box" of the Rio Salado (1N.2W.7.131) is different from any other water in the area in that it is a sodium chloride water with high dissolved solids. This spring is from an area characterized by water bubbling up through sand and gravel in the bed of the Rio Salado. The "box" is cut through steeply, dipping Pennsylvanian limestones, and the spring water probably comes by artesian flow from the limestone. It has a temperature of 70 degrees F (21.1 degrees F (21.1 degrees C) which is at least 10 degrees F (5.5 degrees C) high for the area. The spring water is in equilibrium with calcite, although it is rather high in sulfate.

San Lorenzo arroyo has some interesting springs where the occurrence of sodium bicarbonate waters suggests that the volcanic rocks are acting as cation exchangers.

The thermal springs at Socorro are of interest for several reasons: 1) their temperatures are about 90 to 91 degrees F (32 to 33 degrees C) which is significantly higher than the average annual air temperature of 58 degrees F (15 degrees C), 2) they are sodium bicarbonate waters with low dissolved solids, and 3) two of them supply a large part of water for the city of Socorro and apparently have done so since pre-Spanish days. The two large springs, Sedillo or Evergreen (3S.1W.22.131) and Socorro (3S.1W.22.113), have flows in excess of 200 gpm (757 liters per minute) and lie on definite fault zones. The water-bearing formation is a rhyolitic breccia. Cook Spring (3S.1W.15.313) has a much smaller flow, and flows from an adit which was driven to intercept the water. A well in Blue Canyon (3S.1W.16.323) was drilled into the same breccia, and yields the same type of water. The waters are a sodium bicarbonate type with low dissolved solids. Tritium studies indicate a probable transit time of about 4 years, from recharge along the east flank of the Magdalena Range, to exit at the springs. The waters in the recharge area are calcium bicarbonate waters, whereas, the spring waters are a sodium bicarbonate type; a cation exchange in the reservoir is the probable cause.

E. Vegetation

1. Aquatic Vegetation

Plants common to aquatic and semi-aquatic environments are classified into three categories.

Vascular plants commonly associated with high moisture areas (e.g., along drainages) include grasses such as alkali sacaton, galleta, vine mesquite and saltgrass, sedges, rushes, forbs, such as desert baileya and shrubs including apache plume, skunk bush, rabbitbrush, and salt cedar.

Phytoplankton are microscopic plants that occur in all water systems. These plants are free floating and can usually be classified as green or blue-green algae.

Hydrophytes (floating plants) occur in the more permanent reservoirs, tanks, wells, and springs. Duckweeds, water meal, water fern, and mosquito fern.

2. Terrestrial Vegetation

The area can be classified into six broad vegetative communities or types (Map II-7) and will be discussed in order of size (Table II-5). Within each vegetative type, the species composition (Table II-6) varies due to soils, elevation, exposure, temperature, and precipitation.

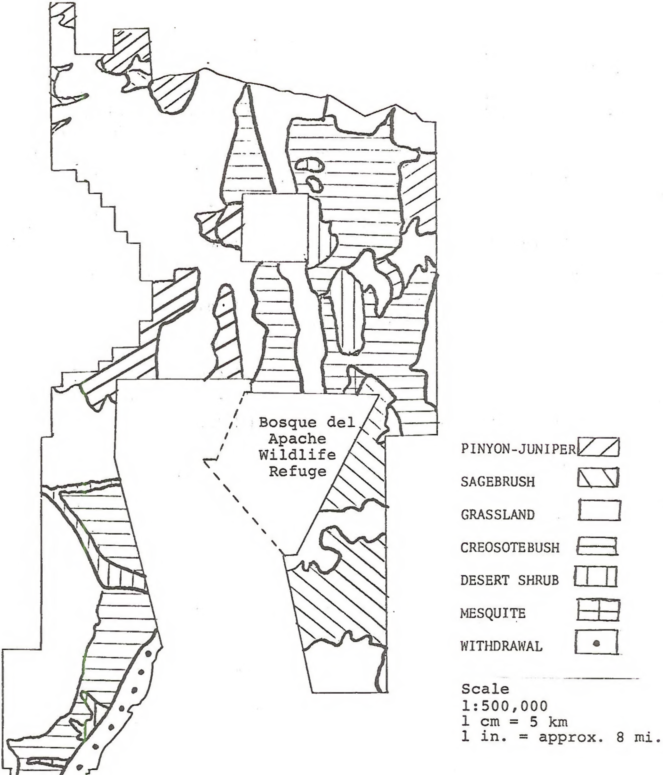
Grassland Type - This is the largest vegetation type in the proposed lease area. Grasses in this type may grow in pure or mixed stands. Many shrubs and forbs occur in this type, but do not make up a large percentage of the vegetative cover. Important plant species include: black grama, blue grama, galleta grass, sand dropseed, mesa dropseed, spike dropseed, alkali sacaton, fluffgrass, burrowgrass, three-awns, mesquite, creosote, juniper, tarbush, snakeweed, desert willow, four-wing saltbush, several species of cacti, various annual forbs, and grasses.

Creosotebush Type - The second largest type is nearly as extensive as the grasslands. This type occurs in dry rocky soils and on slopes with southern aspects. Many other plant species may be associated with creosotebush, but they rarely make up more than 25 percent of the total vegetative cover. Snakeweed, mesquite, four-wing saltbush, yucca, black grama, bush muhley, mesa dropseed, fluffgrass, several species of cacti, and numerous annual grasses and forbs are generally found in this type.

Pinyon-Juniper Type - The third largest type is dominated by juniper with some pinyon. Major species include: black grama, blue grama, sideoats grama, galleta grass, fluffgrass, spike dropseed, three-awn, skunkbush, saltbush, cacti, snakeweed, and many annuals.

Sagebrush Type - This type is characterized by sandy soils. The most important plant species is sand sage. Other species include: sand dropseed, mesa dropseed, black grama, blue grama, broom dalea, skunkbush, saltbush, juniper, snakeweed, annual grasses, and forbs.

Desert Shrub Type - The desert shrub type is very diverse. Many different species are commonly found in this type, but no one species dominates. These species may include: juniper, wolfberry, apache plume, yucca, creosotebush, cacti, black grama, sideoats grama, blue grama, bush muhley, Indian ricegrass, little bluestem, sand dropseed, three-awns, and many annuals.



MAP II-7

VEGETATIVE TYPES

TABLE II-5

VEGETATIVE TYPE DISTRIBUTION

Vegetative Type	Acres	Hectares	Percent of Total Acres
Grassland	175,422	70,993	48
Creosotebush	91,366	36,976	25
Pinyon-Juniper	36,546	14,790	10
Sagebrush	32,892	13,311	9
Desert Shrub	18,273	7,395	5
Mesquite	767	311	.5
Withdrawal	9,137	3,698	2.5
	364,403	147,474	100

TABLE II-6 (Sheet 1 of 3)

PLANT LIST

Grasses

Aristida spp.	three-awn
Bouteloua curtipendula	side-oats grama
Bouteloua eriopoda	black grama
Bouteloua gracilis	blue grama
Hilaria jamesii	galleta grass
Hilaria mutica	tobossa grass
Muhlenbergia porteri	bush muhly
Oryzopsis hymenoides	Indian ricegrass
Schizachyrium scoparium	little bluestem
Schleropogon brevifolius	burrograss
Sporobolus airoides	alkali sacaton
Sporobolus contractus	spike dropseed
Sporobolus cryptandrus	sand dropseed
Sporobolus flexuosus	mesa dropseed
Sporobolus giganteus	giant dropseed
Tridens pulchella	fluffgrass

TABLE II-6 (Sheet 2 of 3)

Shrubs

Atriplex canescens	four-wing saltbush
Chilopsis linearis	desert willow
Dalea scoparia	broom indigobush
Fallugia paradoxa	Apache-plume
Flourensia cernua	tarbush
Gutierrezia sarothrae	broom snakeweed
Juniperus monosperma	one-seeded juniper
Larrea tridentata	creosotebush
Lycium spp.	wolfberry
Opuntia spp.	cactus
Prosopis juliflora	mesquite
Rhus trilobata	skunkbush sumac
Yucca spp.	yucca

TABLE II-6 (Sheet 3 of 3)

Threatened and Endangered Species

Plants Known to Exist in Area:

Petalostemum scariosum - Socorro County, 1 mile south of exit to La Joya Game Refuge, near Carthage - 7 miles south of U.S. 380, T. 5 S., R. 2 E., Section 15

Silene plankii - NE cliffs of Socorro Peak and Strawberry Peak

Rosa stellata - Chupadera Mesa

Limonium limbatum - Alkali soils - Valencia County

Plants Probably Present in Area:

Helianthus lacinatus spp. *crenatus*

Helianthus praetermissus

Perityle staurophylla

Pediocactus papyracanthus

Cleome multicaulis

Draba mogollonica

Astragalus castetteri

Astragalus siliceus

Argemone pleiacantha pinnatisecta

Scrophulaia coccinea

Aletes filifolius

Mesquite Type - This type occupies the smallest area in the proposed geothermal lease area. The dominant plant is mesquite. Vegetation between individual mesquite plants is relatively sparse. Other plant species found in this type include four-wing saltbush, snakeweed, yucca, creosotebush, sand dropseed, mesa dropseed, bush muhley, fluffgrass, many annual grasses, and forbs.

F. Animals

1. Introduction

A wide variety of animal species is found within the assessment area. The subject area is located within the Lower and Upper Sonoran Life Zones and borders the Transition Life Zone associated with the Magdalena Mountains.

Five major wildlife habitat areas (WHAs) have been identified within the area; and these roughly correspond to the major biotic communities found in the subject area (Map II-8).

a. Polvadera-Socorro-Magdalena Mountains - WHA-1A,B,C

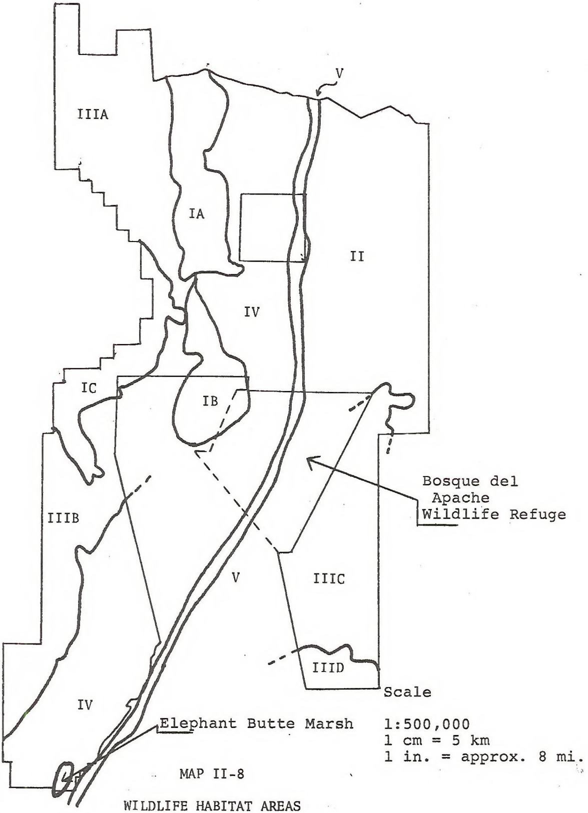
The Polvadera-Socorro-Magdalena Mountain complex provides a variety of habitat for several species of animals. Water is not well distributed in this area. The community is comprised of approximately 82,000 acres (33,185 hectares). It has been divided into three sub-areas.

Highly desirable vegetative species which provide both food and cover include pinyon pine (Pinus edulis), juniper (Juniperus spp.), mountain mahogany (Cercocarpus spp.), Apache plume (Fallugia paradoxa), skunk bush (Rhus trilobata), littleleaf sumac (Phus microphylla), algerita (Berberis spp.), oak (Quercus spp.), and many other vegetative species including grasses and forbs.

Several springs and seeps are located in the mountain complex. Some of the more important springs are located at the base of Socorro Mountain on the Socorro Grant. These springs serve as an important part of the water supply for the city of Socorro.

b. The Jornada River Breaks - WHA-II

The Jornada River Breaks are located east of the Rio Grande and form some of the major drainages leading into the river from the east. A majority of this land is rough and



MAP II-8

WILDLIFE HABITAT AREAS

MAP II-8 LEGEND

WILDLIFE HABITAT AREAS

- I Mountainous Areas
  - IA Polvadera-Socorro Mountains
  - IB Chupadera Mountains
  - IC Magdalena Mountains
- II Jornada River Breaks
- III Grassland Shrub Areas
  - IIIA La Jencia
  - IIIB Mulligan Gulch
  - IIIC Sand Mountain
  - IIID Jornada Lava Flow
- IV Creosote Type
- V Rio Grande Valley

broken with a variety of vegetation. Elevation ranges from approximately 4,600 feet (1,402 meters) on the western side of the WHA to about 5,900 feet (1,798 meters) in the hills that are located in the east central part of the WHA. Vegetation is comprised of pinyon and juniper, desert shrub, creosote, and grassland. The arroyos are important for all species of wildlife found in the area because they afford excellent cover and food. This portion of the assessment area includes approximately 167,200 acres (67,584 hectares).

c. Grassland Shrub Areas - WHA-III

This WHA is divided into four sub-areas and is comprised of approximately 218,400 acres (88,386 hectares). With the exception of the Jornada Lava Flow area, the terrain is flat to rolling and varies from approximately 4,800 feet (1,463 meters) to approximately 6,000 feet (1,828 meters) between the four sub-WHAs.

Some of the vegetation species that are common in the WHA include sand dropseed (Sporobolus cryptandrus), alkali sacaton (Sporobolus airoides), various species of muhly (Muhlenbergia spp.), gramas (Bouteloua spp.), sand sage (Artemisia filifolia), four-wing saltbush (Atriplex canessens), rabbitbrush (Chrysothamnus nauseosus), winterfat (Eurotia lanata), snakeweed (Gutierrezia sarothrae), and yucca (Yucca spp.). Oak is quite abundant in parts of Nogal Canyon south (T. 9 S., R. 3 W.).

This WHA is the best antelope habitat in the assessment area.

d. Creosote Area - WHA-IV

The creosote WHA is comprised primarily of creosotebush (Larrea tridentata) on the flats intermixed with grass and various shrubs, particularly in the arroyos. Generally, the creosote WHA is of poor quality for most wildlife species. The arroyos are the most important part of the habitat since these areas generally have herbaceous and woody vegetation that is desirable for a variety of wildlife species.

e. Rio Grande Valley - WHA-V

This WHA is typical bosque-riparian habitat found along the Rio Grante. The river is characterized by channelization with irrigation channels radiating out to agricultural land in the San Acacia, Socorro, and San Antonio areas. At the present time there is no agricultural land south of the Bosque del Apache Refuge; thus, there is not any system of irrigation channels in this area. However, the river has been channelized to the narrows of Elephant Butte Reservoir. Vegetation adjacent to the river is characterized by dense stands of salt cedar (Tamarix spp.) interspersed with willow (Salix spp.) and cottonwood (Populus spp.). There is no understory in the salt cedar, but somewhat more understory is available in the less dense willow thickets. A greater amount of understory is found in the cottonwood groves.

This WHA includes approximately 14,800 acres (5,989 hectares). It is estimated that about 2,000 acres (809 hectares) is quality aquatic habitat. Almost the entire 2,000 acres (809 hectares) are on Bureau of Reclamation withdrawn lands.

An area of high interest by the public is the Elephant Butte Marsh Area which is located near the southern boundary of the assessment area. The Bureau of Land Management and the Bureau of Reclamation have a cooperative agreement for the BLM to manage the wildlife habitat on 680 acres (275 hectares) of Bureau of Reclamation land. In the early 1970s, this area was recognized as being potentially suitable for development of habitat for the Endangered Mexican duck (Anas diazi). Since that time, the area has been identified as being extremely valuable for several rookery nesting species such as the double-crested cormorant (Phalacrocorax olivaceus) (New Mexico State Endangered Species List), great egret (Casmerodius albus), snowy egret (Leucophoyx thula) and the black-crowned-night heron (Nycticorax nycticorax).

The Elephant Butte Marsh Area is also characterized by a fluctuating water level from season to season and year to year.

In addition, the marsh area provides nesting habitat for approximately 35 other species of birds. Numerous other animal species are also found in association with the Elephant Butte Marsh Area.

A list of animal species occurring or likely to occur within the assessment area is found in the Stallion Unit Resource Analysis. Table II-7 shows the major species found in each WHA and the common name of each game, endangered, threatened, season of use, habitat, distribution and population trend.

TABLE II-7 (Sheet 1 of 6)

MAJOR WILDLIFE SPECIES IN ASSESSMENT AREA

(Major wildlife species found in the assessment area showing distribution, characteristic habitat, season of use and population trend)

Common Name	Distribution by Habitat Area	Characteristic Habitat	Season of Use	Population Trend
Mallard 3/	All	Ponds, reservoirs	M-S, F, W	s
Blue-Winged Teal 3/	All	Ponds, reservoirs	M-S, F, W	s
Pintail 3/	All	Ponds, reservoirs	M-S, F, W	s
Shoveler 3/	All	Ponds, reservoirs	M-S, F, W	s
Western Spadefoot toad	All	Near streams, lakes, reservoirs, rivers	YL	u
Plains Spadefoot toad	All	Temporary and permanent water	YL	u
Waterstrider	All	Permanent water	U	u
Damsel Fly	All	Permanent water	U	u
Dragon Fly	All	Permanent water	U	u
Mosquitoes	All	Permanent water	U	u
Mule Deer 3/	I, II, IIID, V	P-J, brush, mountains	YL	d
Bobcat	I, II, V	Rimrock, bosque areas	YL	s
Coyote	All	All types	YL	i
Mountain Lion 3/	I	Mountains and forests	YL	i

TABLE II-7 (Sheet 2 of 6)

Common Name	Distribution by Habitat Area	Characteristic Habitat	Season of Use	Population Trend
Cottontail Rabbit	All	Grass, brush, P-J	YL	s
Jackrabbit	All	Open, sparsley vegetated	YL	s
Striped Skunk 4/	All	Semi-open, mixed woods, brush, open prairie	YL	s
Woodrat	II, III, IV, V	Semi-arid brushland, cacti, mesquite valley and plains	YL	s
Gambel Quail 3/	II, V	Thickets near water	YL	s
Scaled Quail 3/	All	Grassland, brush, arid	YL	s
Harlequin Quail 3/	I	Wooded mountain slopes with bunch grass	YL	u
Goshawk	I, V	Forests, woodlands in mountains	M-SP, F	u
Cooper's Hawk	I, V	Woodlands, canyons, river groves	M-SP, F	u
Sharp-shinned Hawk	I, V	Forests and thickets	YL	u
Red-tailed Hawk	All	Open country, woodland, mountain, desert	YL	s
Golden Eagle	All	Mountains, foothills, plains	YL	u
Mourning Dove	All	All types	YL	s

TABLE II-7 (Sheet 3 of 6)

Common Name	Distribution by Habitat Area	Characteristic Habitat	Season of Use	Population Trend
Collared Lizard	I, II, IV	Rocky areas in canyons, gullies, mountain slopes	YL	u
Western Diamondback Rattlesnake	All	Desert grassland, brushland, woodland	YL	s
Bullsnake	All	Lowlands to high mountains	YL	u
Kangaroo Rat	II, III, IV, V	Generally sandy soils	YL	u
Badger 4/	All	Open grassland, deserts, foothill areas	YL	s
Red Fox 4/	All	Mixture of forest, woods, open country	YL	s
Swainson's Hawk	III	Dry plains, range land	SP, S, F	s
Marsh Hawk	II, III, IV, V	Marshes, fields, prairies	SP, S, F	s
Great Horned Owl	All	Forests, open country, deserts, canyons, cliffs	YL	s
Prairie Rattlesnake	I, II, IV, V	Grassland, woodland to forests, avoids deserts.	YL	s
Lesser Earless Lizard	II, III, IV	Plains areas with exposed sand or gravel	YL	s
Eastern Fence Lizard	II, III, IV, V	Forest, prairies, brushy flatlands, sand dunes	YL	u
Killdeer	All	Fields, lawns, river banks, shores, irrigated land	YL	s
Antelope 3/	III	Open prairie, open brushy areas	YL	s

TABLE II-7 (Sheet 4 of 6)

Common Name	Distribution by Habitat Area	Characteristic Habitat	Season of Use	Population Trend
Prairie Horned Lark	II, III	Plains, desert prairies, fields	YL	s
Great Plains Skink	All	Grassland and woodlands, plains to mountains	YL	u
Western Box Turtle	II, III, IV	Prairies and treeless plains	YL	s
Common Night-Hawk	All	Treeless plains to mountains	SP, S, F	
Raccoon 4/	V	Along streams and lakes with trees	YL	s
American Avocet	III, V	Marshes, mud flats, alkaline lakes	SP, S, F	s
Long-billed Curlew	II, III, IV	High plains, range lands	M-SP, F	s
Black-necked Stilt	III, V	Marshes, mud flats, alkaline lakes	SP, S, F	s
Couch's Spade-foot Toad	II, III, IV	Short grass, mesquite creosote	YL	u
Plains Spade-foot Toad	All	Plains, hills, river bottoms, short grass, temporary and permanent water	YL	u
Great Plains Toad	II, III, IV	Prairies or deserts	YL	s

TABLE II-7 (Sheet 5 of 6)

Common Name	Distribution by Habitat Area	Characteristic Habitat	Season of Use	Population Trend
Gray Fox 4/	I, II, V	Brush, open forests, rimrock country	YL	s
Sparrow Hawk	All	Prairies, deserts, farmland	YL	s
Greater Earless Lizard	II, IV	Cactus, mesquite, creosote	YL	s
Checkered Whiptail	I, II, III, IV	Creosote to P-J	YL	u
Mexican Duck 1/	V	Fresh water marshes, ponds, streams	SP, S, F	D
Double Crested Cormorant	V	Large lakes, marshes with trees	SP, S, F	i
Olivaceous Cormorant 2/	V	Large lakes, marshes with trees	SP, S, F	i
Great Egret	V	Marshes, ponds with trees	SP, S, F	i
Snowy Egret	V	Marshes, ponds with trees	SP, S, F	i
Bell's Vireo 2/	V	Willow thickets along woodland streams, mesquite	S	u
Black-crowned Night Heron	V	Marshes, ponds with trees	Sp, S, F	i
Bald Eagle 1/	III, V	Lakes and rivers, open plains	W, M-SP, F	D
Bullfrog 3/	V	In or near permanent water	YL	s

TABLE II-7 (Sheet 6 of 6)

Common Name	Distribution by Habitat Area	Characteristic Habitat	Season of Use	Population Trend
Tiger Salamander	V	Adjacent to streams and ponds	YL	u
Painted Turtle	V	Ponds, marshes, small lakes, streams	YL	u
Common Garter Snake	V	Ponds, marshes, sloughs, damp meadows	YL	u
Carp	V	Streams, marshes, reservoirs	YL	u
Bullhead Catfish	V	Streams, marshes, reservoirs	YL	u
Little Blue Heron 2/	V	Marshes, ponds with trees	SP, S, F	s

1/ Endangered - U. S. List
2/ Endangered - N. M. List
3/ Game Species
4/ Furbearer

M - Migration
SP - Spring
S - Summer
F - Fall

W - Winter
YL - Yearlong
U - Unknown

d - Decreasing
i - Increasing
u - Unknown
s - Stable

2. Aquatic Species

a. Mammals

With the exception of WHA-V, habitat for aquatic mammals is generally scarce and of low quality. Habitat is in the form of stock water reservoirs, springs, and temporary water in arroyos and desert streams. An occasional raccoon would be the primary aquatic species found in this type of habitat.

The beaver (Castor canadensis), raccoon (Procyon lotor), and muskrat (Ondatra zibethica) are the aquatic mammal species that heve been identified in this part of the assessment area. These species are most likely to be found in the vicinity of the irrigation channels and Elephant Butte Marsh.

b. Birds

Stockwater reservoirs provide a limited amount of habitat for waterfowl and shorebirds. The mallard (Anas platyrhynchos), blue-winged teal (Anas discors), pintail (Anas acuta) and the shoveler (Spatula clypeata) are the waterfowl species found in this type of habitat.

One of the most important aquatic habitat areas in the assessment area and the entire state, is the area known as Elephant Butte Marsh (located in WHA-V). This area provides nesting habitat for three endangered species, the Mexican duck (U.S. list), little blue heron, and Olivaceous cormorant (both on N.M. State list). The marsh area is also valuable nesting habitat for black-crowned night herons, double-crested cormorants, snowy egrets, and common egrets. Several bald eagles have been observed to use the area during the winter. At least 35 other species of birds are known to nest in or around the marsh area (Hundertmark, 1975).

For a more complete description of the Elephant Butte Marsh Area see the Stallion URA.

Waterfowl hunting is quite popular along some of the irrigation channels and the Elephant Butte Marsh Area. It is estimated that approximately 35 percent of the ducks harvested in Socorro County are taken within the assessment area.

The Bosque del Apache Refuge is adjacent to the assessment area and is one of the most important migratory bird refuges in the southwestern states. Its importance has increased as a result of the experimental whooping crane (endangered species) foster parent program. This refuge is primarily a wintering area for most birds; however, the endangered Mexican duck is also known to nest there during the spring and summer.

c. Amphibians and Reptiles

Couch's spadefood toad (Scaphiopus couchi), plains spadefood toad (Scaphiopus bombifrons) and great plains toad (Bufo cognatus) are commonly found in or near stockwater reservoirs and desert streams.

The Elephant Butte Marsh Area provides excellent aquatic habitat for amphibians. The irrigation channels and the river provide fair aquatic habitat when there is water. Species common to this aquatic habitat include the bullfrog (Rana catesbeiana), western spadefoot toad (Scaphiopus hammondi), plains spadefoot toad, and the tiger salamander (Ambystoma tigrenum).

The painted turtle (Chrsemys picta), spiny softshell (Trionyx spiniferus) (N.M. State list) and the common garter snake (Thamnophis sutalis) are common reptiles in the assessment area.

d. Fish

Carp (Cyprinus carpio), bullhead catfish (Ameiurus spp.), black bass (Micropterus salmoides), and gizzard shad (Dorosoma cepedianum) are common in Elephant Butte Marsh. Carp and catfish are found in some of the irrigation channels and the river when there is water.

e. Invertebrates

A variety of aquatic invertebrates are present. Conversation with Dr. John Hubbard of the New Mexico Department of Game and Fish indicates there may be an endangered snail (Amnicola neomexicana) inhabiting one of the springs. However, Dr. Hubbard believes that the snail probably no longer exists because the springs have been developed. He reportedly observed the springs recently and was unable to locate the snail in question.

Another aquatic invertebrate has also been identified to inhabit Sedillo Spring. The brown pill bug (Exosphaeroma thermophilum) has been identified by Dr. Hubbard recently. This is the only place in the U.S. where this species is known to occur. According to Dr. Hubbard, the brown pill bug would be proposed for inclusion on the U.S. and State Endangered Species lists.

3. Terrestrial Species

a. Mammals

A wide variety of terrestrial mammal species are found in the assessment area.

Deer are generally found in the mountains, foothills, and bosque area. The deer population is low and is estimated at one (1) deer per section in the deer habitat (WHA-I, II, V - see Map II-8).

A relatively small and stable antelope population is found in the flat to rolling areas of the assessment area (WHA-III). An antelope hunt was conducted by the New Mexico Department of Game and Fish in October, 1976 in part of WHA-IIIA, B as shown in Table II-8. Permits are issued to hunt antelope approximately every 2 or 3 years in WHA-IIIA depending on the fawn crop and the buck to doe ratios as determined by aerial census.

Other mammal species commonly found over most of the assessment area include the following: coyote, jackrabbit, desert cottontail, kangaroo rat, skunks (Spilogale putarius) and (Conepatus leuconotus), chipmunk (Eutamias spp.), woodrat (Neotoma spp.) badger, and gray fox. Mountain lion and bobcat are less abundant and may be found in the more mountainous areas. The bobcat is also found in the bosque area (WHA-V).

b. Birds

A wide variety of bird life is found in the assessment area.

Scaled quail are found in nearly all of the habitat areas with the greatest concentrations being near the river and to the eastern boundary of the assessment area.

Gambel's quail are generally found near the thick brush in the vicinity of the bosque and brushy draws. Mesquite and salt cedar are used for cover by Gambel's quail along the

TABLE II-8

MAJOR GAME SPECIES HARVEST

(1974 harvest data for mourning dove, quail and waterfowl. Harvest data for antelope is from the 1976 information. Harvest data is projected for the assessment area.)

Species	Hunt Area	Harvest
Mourning Dove (1)	Socorro County	5,939
Quail (1)	Socorro County	3,355
Waterfowl (2)	Socorro County	2,873
Antelope (3)	La Jencia Mulligan Gulch (Area No. 16-1,3)	Not available at present

river. In the arroyos, Gambel's quail use skunkbush, Apache plume, four-wing saltbush, and mesquite for cover.

Food for both species of quail is plentiful and is found in the form of seeds, such as tansymustard, snakeweed, pigweed, mesquite, and Russian thistle. One observation of Harlequin quail has been recorded on the northeast side of the Magdalena Mountains (WHA-1C) adjacent to the assessment area.

Quail hunting reflects the customary fluctuations associated with these species. During periods of high populations, the quail hunting is excellent in many parts of the assessment area (Table II-8).

Mourning doves are present yearlong. During the winter months, population densities decrease considerably, with the highest population numbers occurring during the late summer-fall migration. The bosque area (WHA-V) is considered as critical nesting habitat for the mourning dove. The salt cedar, willow, and cottonwood trees are also used for nesting sites by many other species of birds. It is estimated that at least 50 percent of the quail and doves taken in Socorro County are harvested within the assessment area. Dove hunting is generally good to excellent in most parts of the assessment area (Table II-8).

Several raptors inhabit the assessment area during migration or yearlong. The goshawk (Accipiter gentilis), Cooper's hawk (Accipiter cooperii), sharp-shinned hawk (Accipiter striatus), red-tailed hawk (Buteo jamaicensis), Swainson's hawk (Buteo swainsoni), marsh hawk (Circus cyaneus) and great horned owl (Bubo virginianus) are common. The Bald eagle (Haliaeetus leucocephalus) and golden eagle (Aquila chrysaetos) are observed to migrate or winter in the assessment area. The prairie falcon (Falco mexicanus) is known to nest in the San Lorenzo Canyon area. Many other bird species are found in the assessment area. Included would be prairie horned larks (Eremophila alpestris), various species of hummingbird (Trochilidae), woodpecker (Picidae), flycatcher (Tyrannidae), swallow (Hirundidae), warbler (Parulidae), wren (Troglodytidae) and many other song birds (Passeriformes).

c. Reptiles

Reptiles are numerous in the assessment area. Species commonly found are: bullsnake (Pituophis melanoleucus), western diamondback rattlesnake (Crotalus atrox), prairie rattlesnake (Crotalus viridis), collard lizard (Grotaphytus collaris, lesser earless lizard (Holbrookia maculota), eastern fence lizard (Sceloporus undulatus), great plains skink (Eumeces obsoletus), western box turtle (Terrapene ornata) and checkered whiptail (Cnemidophorus tesselatus).

There are no known threatened or endangered reptiles in the assessment area. At this time, the Jornada Lava Flow has not been inventoried for the presence of threatened, endangered, or unique species.

d. Invertebrates

Numerous terrestrial invertebrates occur. The most common are grasshoppers, beetles, ants, flies, and spiders.

G. Ecological Interrelationships

1. Succession

The most complex plant and animal communities within the Socorro Peak Geothermal Environmental Assessment Area occur within the desert mountains and foothills which border the Rio Grande Valley. Trees, shrubs, forbs, and grasses are present. Wildlife species are quite diverse compared to the plains areas. Physical factors, such as grazing, mining, and recreation have altered plant succession to some degree; however, it is not within the scope of this assessment to determine the seral stages of ecological succession within this area. Biotic-abiotic relationships found within the desert-mountain communities are a very important consideration when discussing ecological interrelationships. The primary abiotic factor which has aided the development of desert-mountain communities, is the increase in precipitation due to the uplift effect that the mountains have on frontal weather systems. Other factors which are less obvious include the ability of rocky soils to trap, store, and hold moisture; and the shading effect of north and east slopes which enable increased density and composition of plant species to occur. These abiotic-biotic relationships are very subtle and are impacted through surface disturbance.

The Rio Grande Valley and adjacent plains biotic communities are less complex. Physical factors injected into the ecosystem by man are more prevalent. General development (roads, fences, and pipelines) as well as agricultural use (grazing, cropland, etc.) has had a profound effect on ecological values within these areas. Alteration by man and periodic droughts have contributed to deteriorated vegetative and wildlife habitat conditions. Much of this deterioration can be attributed to early travelers who settled in the valleys, having limited understanding of proper livestock stocking rates, which created considerable competition for available water and forage. Through this competition, the more palatable plant species were chosen by grazing animals, and less desirable species took their place. This selective grazing, eventually, resulted in nearly monotypic stands of creosote and mesquite in some areas. These species were unable to provide adequate watershed protection, which resulted in increased soil erosion by both wind and water.

It may be assumed that changes instigated by man in vegetative and wildlife resources have resulted in significant alteration and reduction of some plant and animal species within the valleys. Major limiting abiotic factors within these valleys include lack of adequate precipitation, high soil temperature, inability of soils to hold water which is lost as runoff, and depleted soils which are unable to provide for the establishment of desirable vegetative species. Physically altered areas are slow to recover due to limiting factors described above. When perennial vegetation is removed by surface disturbance, annual vegetation becomes established and secondary succession slowly proceeds from this point.

2. Food Relationships

Food relationships are based on the transfer of energy derived from sunlight, water, and soil nutrients into plants which pass through a series of organisms in a very intricate system referred to as a chain. In its most basic form, the dependency of plants and animals upon each other can be readily recognized within the predator food chain. Plant eating animals, such as the kangaroo rat, a herbivore, rely on vegetative production for life. The rat may be consumed by a bullsnake, which may be consumed by a red-tailed hawk. It becomes apparent that the hawk, a tertiary consumer, is dependent indirectly upon plant production. In most cases, the food chain from plant to final consumer does not exceed four steps. Less obvious food chains are the parasitic chains which proceed from larger to smaller animals, and the saprophytic chain, which goes from dead matter to microorganisms. Understanding the interconnection of these chains is essential to understanding food relationships which are referred to as the food web. Energy loss in the form of heat occurs at each food transfer within the chain, resulting in the top consumer in the food chain being fairly scarce within the ecosystem. In a natural food chain, the nutrients complete the cycle within the ecosystem. Nutrients which are taken from the soil by plants and incorporated into proteins as the plant grows, are used by the successive components of the food chain and returned to the soil as nutrients when the last member of the chain dies. When livestock are placed in an ecosystem and then marketed, nutrients are removed from the natural ecosystem. Intensive grazing carried on over a period of years may noticeably deplete the nutrients from an ecosystem.

All primary consumers, both wild and domestic, require a variety of vegetative species for healthy maintenance. The availability of certain plant species during different times of the year is essential to some species for good reproduction (example, antelope require succulent grasses and forbs during early spring for fawn production and doe lactation). There are few primary consumers which can sustain themselves on near monotypic stands of vegetation. Due to this, vegetation limits the degree of development of a food chain within a given area. This further clarifies the reason for more complex animal communities within the desert mountains which have a variety of trees, shrubs, forbs, and grasses.

Another limiting factor in regard to food relationships within the desert southwest is the availability of water. In many cases, water controls the population and distribution of wildlife and livestock within a given ecosystem. Some species, such as scaled quail, have adapted to this type of environment; however, most wildlife species are dependent on some form of free water. During dry months, normally March through June, and during drought periods, livestock reservoirs, intermittent streams, and natural ponds are often dry and the only available water in many areas is that which has been developed by man. Supplementation of natural waters through the development of windmills, pipeline systems, catchments, and large reservoirs, has aided in maintaining wildlife and livestock during these dry periods.

3. Community Relationships

Basic community relationships within the environmental assessment area are based on food, water, and cover requirements of existing plant and animal species as previously discussed. In ecological theory, a community concept is where diverse organisms usually live together in an orderly manner as independent beings.

Desert mountains within the proposed geothermal lease area provide island habitat for numerous biotic communities. Physical disturbance of communities would have a limited effect on those wildlife species capable of moving to other areas which may provide suitable habitat; however, that portion of the biotic community composed of small, less mobile forms of wildlife and immobile plant species would be impacted to a greater degree by actions which alter their environment.

Riparian habitat within the proposed lease area is primarily limited to valley bottoms within the more mountainous areas, dry wash bottoms within the valleys, areas surrounding water developments and dwellings, and Elephant Butte Marsh. Due to the limited extent of this type of habitat, rather complex biotic communities occur within these areas. Animal species particularly associated with these riparian communities include: mammals, (e.g., raccoon); waterfowl, (e.g., Mexican duck, mallard duck); birds of prey, (e.g., Cooper's hawk, and the great horned owl); song birds, (e.g., mockingbird and western kingbird); amphibians (spadefoot toad); and reptiles, (spiny softshell). Due to the limited occurrence of these riparian communities and the specific nature of associated wildlife species habitat requirements, elimination of all or portions of such communities would directly affect existing populations.

H. Landscape Character

1. Open Space

The Rio Grande River Valley meanders southward through the center of the proposed leasing area, producing a green belt of vegetation. The relatively lush vegetative pattern of the Rio Grande bosque lands is supplemented by agricultural lands that occupy the fertile bottom lands. The fertile valley lands are striking in contrast to the surrounding arid lands of the Upper Sonoran Desert life zone.

The desert lands immediately adjacent to the Rio Grande Valley, are characterized by severely eroded breaks and sandy arroyos draining into the river. A multitude of creosote benches are created by drainages feeding the river. As their distance from the river increases, the drainages become fewer and wider, accompanied by the changing landscape features of rolling hills and flat grasslands.

The open spaces throughout the leasing area are created by the low growing desert shrubs and grasses. This unbroken desert landscape generally extends 5 to 10 miles (8 to 16 kilometers) east and west of the Rio Grande. The western boundary of the leasing area is marked by a series of rugged mountains paralleling the Rio Grande on a north-south axis. The extreme southwestern edge is defined by the San Mateo Mountains. Continuing north, the Magdalena, Chupadera, and Socorro Mountains are noticeable projections on the landscape.

The eastern desert lands bordering the Rio Grande River, duplicate the creosote benches and gravelly arroyos of the west side landscape in the southeast portion of the leasing area. The northern tip of the Fra Cristobal Mountains and the volcanic formation of Black Mesa, provide a sharp vertical contrast to the low lying desert lands. Further east and south five miles from Black Mesa, the worn, once rugged features of a 60,000 acre (24,282 hectares) lava flow dominate the topography. This worn and aged lava flow is covered with pockets of soil and vegetation, characterizing an advanced stage of geological attrition. North of the lava flow to Highway 380, the topography is flat to gently rolling, characterized by sandy soils, with a vegetative aspect of yucca and sagebrush.

The Bosque del Apache Wildlife Refuge consists of 57,191 acres (23,145 hectares), displaying lush river bottom vegetation, and occupies the central portion of the proposed leasing area. The study area north of San Antonio to San Acacia has similar vegetative and drainage patterns. The river valley is dominated by a patchwork of agricultural lands and man-made improvements. Immediately west of Socorro, the volcanic mass of Socorro Peak and lesser formations rise up 7,000 feet (2,134 meters) above the valley floor. On the western side of this small mountain group, is the flat desert grasslands of the La Jencia Plains. This open space extends westward 10 miles (16 kilometers) to the pinyon-juniper foothills of the Bear Mountains. The La Jencia Plains are bracketed on the north by the Rio Salado and the Magdalena Mountains on the south.

The land forms northeast of the Rio Grande are a combination of sandy loam benches, shrub covered hills, and pockets of desert grasslands. Pinyon-juniper is scattered throughout the landscape. The far eastern boundary of the leasing area is defined by the Quebradas Hills, a rugged formation of volcanics and sandstones.

2. Visual Resources

The visual resources of the Socorro Peak Area range from Class II to Class IV (Map-II-9). The visual resource management classes of this area were arrived at through a three-step process involving inventory and evaluation. Briefly, the process is as follows:

a) The visual resources were physically inventoried and given an A, B, or C scenic quality rating: A is highly scenic; B is above average; and C is average.

b) A visual sensitivity level of high, medium, or low is assigned to the resources in the area. It is based on the relative importance of visual response to an area in relation to other areas within the planning unit.

c) Visual zones were delineated as viewed from selected, most frequently traveled routes in the area. These zones were then designated as foreground-middleground, background, or seldom-seen; depending on their distance from the travel route.

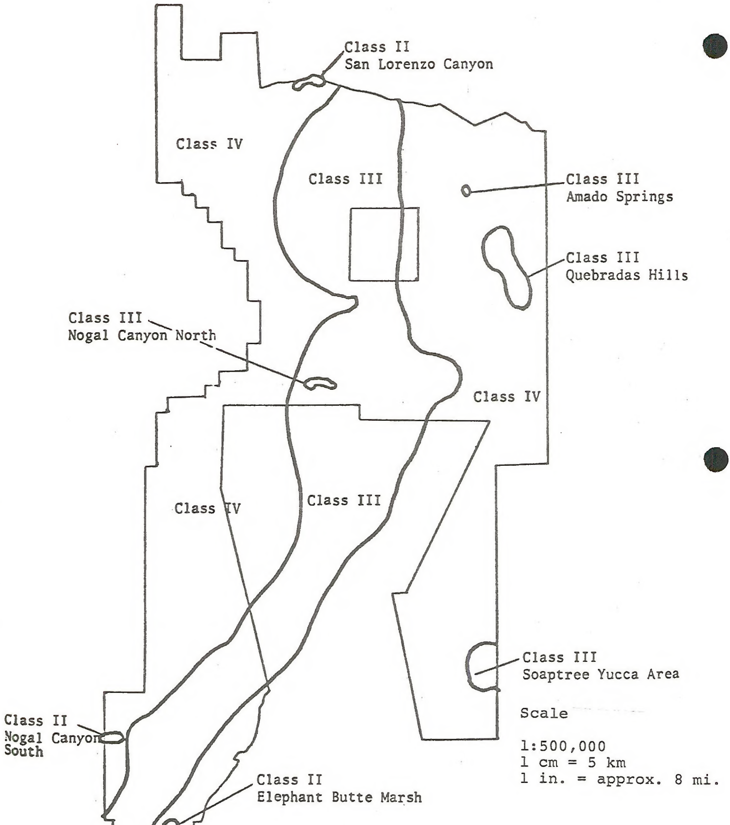
These criteria are placed in a simple matrix (Table II-9) determining the visual resource management classes, which are:

Class II - Changes in any of the basic elements (form, line, color, or texture - see Chapter IIIA for definitions) caused by a management activity should not be evident in the characteristic landscape.

Class III - Changes in the basic elements, (form, line, color, or texture) caused by a management activity may be evident in the characteristic landscape. However, the changes should remain subordinate to the visual strength of the existing character.

Class IV - Changes may subordinate the original composition and character but must reflect what could be a natural occurrence within the characteristic landscape.

Significant scenic areas identified in the Stallion MFP for Class II visual resource management (Map II-9) are the Elephant Butte Marsh, a unique aquatic ecosystem; Nogal Canyon South, a scenic geologic phenomenon in the Southwest; and San Lorenzo Canyon, a scenic geologic canyon. San Lorenzo Canyon has been recommended for Outstanding Natural Area designation.



MAP II-9

CLASS II, III, AND IV VISUAL RESOURCES

TABLE II-9

VISUAL RESOURCE MANAGEMENT CLASS MATRIX

		2/ VISUAL SENSITIVITY LEVEL						
		HIGH			MEDIUM			LOW
SPECIAL AREAS		I	I	I	I	I	I	I
1/ SCENERY CLASS	A	II	II	II	II	II	II	II
	B	II	III	IV	III	IV	IV	IV
	C	III	IV	IV	IV	IV	IV	IV
		FG	BG	SS	FG	BG	SS	SS
		3/ VISUAL ZONES						

1/ SCENERY QUALITY INVENTORY (6310.11)	A, B, C
2/ VISUAL SENSITIVITY LEVEL (6310.12)	High Medium Low
3/ VISUAL ZONES (6310.13)	FG - Foreground-Middleground BG - Background SS - Seldom Seen

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NOTE: Class I applies only to classified special areas, e.g., Wilderness, Primitive, Natural Areas, etc. This quality standard is established through legislation or policy.

Class V applies to areas identified in the scenery quality inventory where the quality class has been reduced because of unacceptable intrusions.

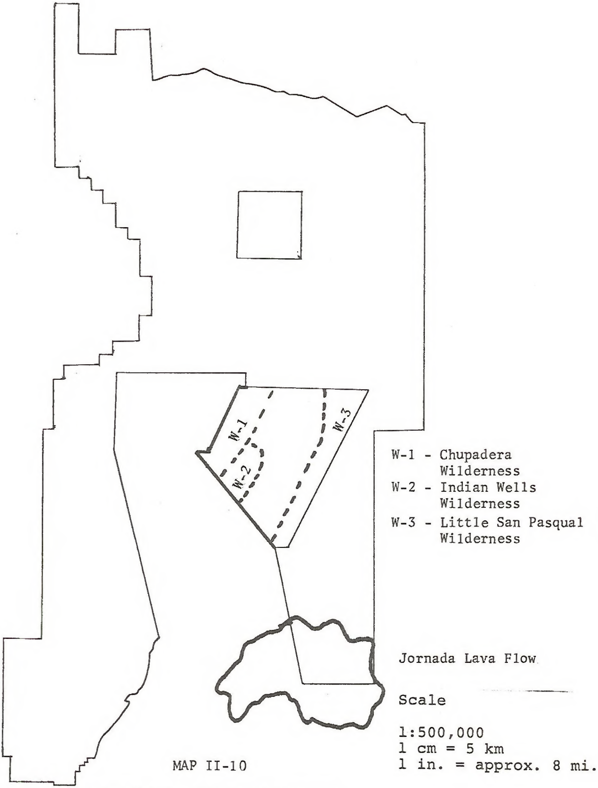
Scenic Class III visual resources (Map II-9) include, Nogal Canyon North, just north of the Pedro Armendariz Grant; Amado Springs, approximately 7 miles (11.2 kilometers) northeast of Socorro; the Soaptree Yucca Scenic Area on the northeast edge of the Jornada Lava Flow, and the Quebradas Hills just east of Socorro.

Also delineated as Class III is a visually sensitive corridor of approximately 3 miles (4.8 kilometers) on each side of I-25, from San Acacia south to the district's southern boundary. Although the scenery within this corridor is average for the Upper Sonoran Desert, it is highly sensitive because of the number of people that view it from I-25, a major north-south New Mexico travel route.

The rest of the proposed leasing area is classified as a Class IV visual resource (Map II-9). This includes desert grasslands, rolling pinyon-juniper hills, the creosote breaks paralleling the Rio Grande, the desert shrub-covered sandy hills, and the multitude of gravelly, sand-bottomed arroyos dissecting the arid desert lands.

3. Primitive Values

Bureau Manual 6221 sets forth general guidelines to follow in identifying potential primitive areas. The criteria used include: 1) the number of intrusions, 2) scenic quality, 3) wildlife, 4) size, and 5) uniqueness. The overriding factor in determining suitability for primitive evaluation is that an area must be 5,000 or more acres (2,024 hectares) in size and essentially roadless. Approximately 14,000 acres (5,666 hectares) of a basaltic lava flow in the extreme southeast portion of the Socorro Peak leasing area qualifies as having significant primitive values to be considered for possible designation. This area is identified in the Stallion MFP as the Jornada Lava Flow, and is recommended to be studied for its primitive values (Map II-10). This relatively undisturbed open space has also been identified by the Wilderness Society as a potential primitive area. The total lava flow encompasses approximately 60,000 acres (24,282 hectares), with one-quarter being in the Socorro District, one-quarter in the Las Cruces District, and 50 percent or more extending west into the Pedro Armendariz Grant. The remaining BLM resources of the Socorro Peak geothermal study area either do not possess primitive values, sufficient size, or are not intrusion-free to the degree which would qualify them for primitive area consideration. It is of interest to note,


W-1
W-2
W-3
W-1 - Chupadera Wilderness
W-2 - Indian Wells Wilderness
W-3 - Little San Pasqual Wilderness
Jornada Lava Flow
Scale
1:500,000
1 cm = 5 km
1 in. = approx. 8 mi.

MAP II-10

PRIMITIVE AND WILDERNESS VALUES

that the Bosque del Apache Wildlife Refuge does contain three designated wilderness areas (Map II-10) totaling 30,287 acres (12,257 hectares). Existence of these natural areas will be taken into consideration during the analysis of the environmental impacts of geothermal leasing on nearby public lands.

J. Land Uses

1. Grazing

The livestock industry is the most important industry in the proposed geothermal lease area. There are 42 allotments with an estimated grazing capacity of 56,000 AUMs. Of the total of 619,913 acres (250,879 hectares) an estimated 90 to 95 percent is suitable or potentially suitable for grazing. Yearlong grazing by cattle has been the most common practice in the past, but recent implementation of Allotment Management Plans by BLM has initiated rotational grazing on some of the area. Grazing capacities currently range from 4 to 8 cattle yearlong (CYL) per section (Table II-10).

2. Rights-of-Way

Transportation - The major roads in the assessment area are I-25, handling north-south traffic, and U. S. Highways 60 and 380, transecting the area east and west. There are many unpaved secondary roads throughout the area. Freight service is provided by the Atchison Topeka and Santa Fe Railroad.

Electric Power Line - El Paso Electric Company has a major power line in the western half of the area that runs north and south. Other lines exist throughout the unit.

Gas Pipeline - There are two natural gas pipelines in the area. One pipeline goes from El Paso to Albuquerque, several miles east of the river. The other serves the Socorro area, going north-south, west of the river.

Communication - There are two underground and many above-ground communication lines. American Telephone and Telegraph Co. has an underground cable crossing the unit from Magdalena, south of San Antonio and then directly east. Mountain Bell has a smaller underground line north of the Pedro Armendariz Grant. Many above-ground lines serve towns and ranches.

TABLE II-10

NUMBER OF GRAZING ALLOTMENTS

AMPs**Needing Revision or are adequate	15
New AMPs Required	25
Custodial***	2
	41

Ownership and Present Estimated Grazing Capacity

	Acres	CYL
Federal	366,572	3,133
Private	136,328	795
State	117,013	743
	619,913	4,671

**(Allotment Management Plan) - An allotment with implemented grazing plan conducted in order to reach specific management objectives.

***Custodial - Operator controlled allotment with little BLM input.

3. Urban and Suburban

The majority of the urban and suburban population is in Socorro with a population of 5,849 (1970 census). This town is the major service center for the area. Other towns are San Antonio (320), Lemitar and Polvadera (both with less than 200), and Luis Lopez and Escondida (both with less than 100). Magdalena, just outside the assessment area, is the second largest town in the area with a population of 1,200. Lands used for urban and suburban purposes is a very small percentage of the total area (Map II-11).

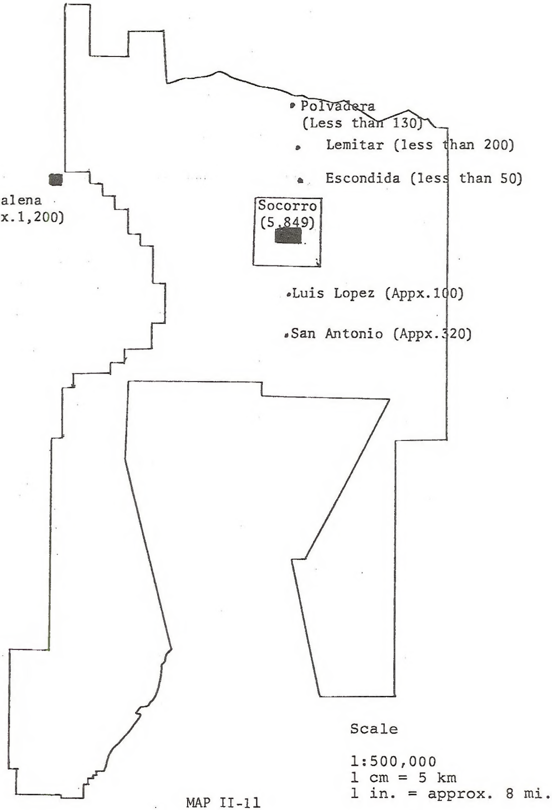
4. Recreation

Recreation use on a majority of the lands within the proposed leasing area is of a dispersed type. The only organized and controlled recreation occurs within the city limits of Socorro and within the Bosque del Apache Wildlife Refuge. There are no developed recreation sites on National Resource Land (NRL) within the proposed leasing area.

The dominant form of recreation is hunting. Quail, dove, pheasant, rabbit, squirrel, turkey, deer, and bear are the most popular and often hunted game. Predator and varmint shooting are also popular forms of recreation. Some waterfowl hunting and fishing occur along the river valley, bosque drainages, and water tanks.

The San Mateo and Magdalena Mountains on the western border of the proposed lease area, are favorite deer hunting grounds. The Rio Grande bosque lands, particularly those south of San Antonio, also receive heavy deer hunting pressure. Scattered pinyon-juniper areas in the northeast portion of the leasing area provide suitable deer hunting.

Waterfowl hunting occurs primarily along the Rio Grande, from San Acacia to Elephant Butte Marsh. Quail and dove hunting opportunities are generally favorable area-wide, depending on the previous year's climatic conditions and their effect on the bird's reproduction cycle. Private croplands throughout the valley provide additional hunting opportunities in the form of pheasant and goose hunting. Varmint and coyote hunting opportunities are also spread over the entire area. Other forms of recreation and some areas associated with them include: birdwatching in the Elephant Butte Marsh, Bosque del Apache Wildlife Refuge, and area-wide, sightseeing and photography in the San Mateo Mountains, Bosque del Apache Wildlife Refuge, San Lorenzo



MAP II-11

POPULATION CENTERS

Canyon, Elephant Butte Marsh, and area-wide; ORV use in the Rio Grande River bottom, breaks and arroyos; east and west sides of river, and area-wide; camping and hiking in the Magdalena Mountains, San Mateo Mountains, and San Lorenzo Canyon; and fishing in the Elephant Butte Marsh, Rio Grande River, and the Bosque del Apache Wildlife Refuge.

As previously stated, most of the recreation use is dispersed and actual visitor use figures are "guesstimates" at best. Recreation use in the proposed leasing area is expected to steadily increase in the future. The recreation opportunities offered by the public lands is inexpensive and abundant. Unless the national economy experiences a drastic setback, recreation use of the public lands would continue to be an important and frequent use of the resources.

K. Cultural Resources

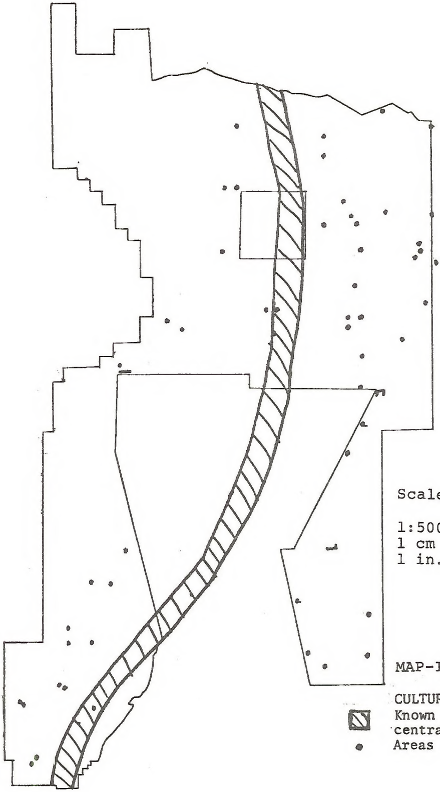
1. Identification and Evaluation Procedures

Cultural Resources identified in the project area are known through existing data contained in the Cultural Resource Inventory System of the BLM Socorro District. This information is based upon the cumulative field inventories of the BLM Socorro District Office and the Museum of New Mexico, Laboratory of Anthropology.

More cultural resources will be identified through future reports and systematic sample surveys. Dr. Robert Weber of NMIMT is scheduled to complete a report on Paleo-Indian and Archaic cultures by March 31, 1977. The survey being performed by New Mexico State University for the Grazing ES overlaps the area for this survey; this survey is to be completed by February 28, 1977. Another survey to identify cultural resources in the Geothermal EAR area is scheduled to be completed by March 31, 1977 (Map II-12).

The current listing of the National Register of Historic Places, as published in the Federal Register February 10, 1976, was reviewed to determine the presence or absence of National Register properties in the project area. Consultation with the State Historic Preservation Officer to determine the presence of other cultural resources was initiated on November 4, 1976.

The evaluation of cultural resources would be performed by the Socorro District Archaeologist based upon the data contained in the site inventories.



Scale

1:500,000
1 cm = 5 km
1 in. = approx. 8 mi.

MAP-II-12

CULTURAL RESOURCES

▨ Known areas of site concentration.

● Areas to be surveyed.

2. Ethnographic Summary

Presently it appears that the area has a cultural history of at least 12,000 years. More information would be available after surveys are completed.

3. Summary of Known Cultural Resources

There are four National Register properties in the area of the proposed action. All are privately owned. The Bursum House, Garcia Opera House, and Illinois Brewery are located in the town of Socorro. Ft. Craig, in operation during the Civil War and the days of Apache raiding, is located 37 miles south of Socorro.

The Johnson Hill Pueblo, Bell Mountain Site, Site No. AR-NM-02-205, and Site No. AR-NM-02-348 are prehistoric sites that have been identified as eligible for nomination to the National Register of Historic Places. All are on National Resource Lands.

4. Other Cultural Resources

In addition to the cultural resources discussed above, several other cultural properties are known to exist in the project area. Current information is limited on these areas. Additional information will be available after completion of the on-going cultural resource surveys.

5. Unknown Cultural Values

The nature of the existing inventory makes it highly probable that additional cultural values exist in the project area. The majority of known sites are located on private land near the Rio Grande. The systematic sample surveys designed for the Grazing ES and the Geothermal EAR areas, should provide data adequate to estimate the nature and distribution of cultural resources in the unit.

L. Other Considerations

There are several educational, scientific, and recreational values in or near the assessment area that are important, but not on NRL. The New Mexico Bureau of Mines is located on the New Mexico Tech Campus. Langmuir Laboratory, based out of New Mexico Tech, is an atmospheric research center located on Baldy Mountain in the Magdalena range. On the area's southeastern boundary is White Sands Missile Range, location of the first atomic explosion. In the south central part of the area are Bosque del Apache Wildlife Refuge and Elephant Butte Marsh; both noted for their wildlife.

There is a perlite mine west of Socorro. Mineral prospecting goes on throughout the area. Mining presently is a very small part of the economy. There is some oil and gas leasing in the area but no oil has been discovered.

III. ANALYSIS OF PROPOSED ACTION

A. Environmental Impacts

1. Air

a. Anticipated Impacts

Impacts to air quality during pre-lease exploration should be very low. They would consist mostly of increased dust caused by vehicles or wind. Anticipated increase in geophysical surveys, drilling operations, and off-road travel would introduce into the air some noxious gas released from mechanical combustion, and dust disturbed by movement of vehicles. Noxious gases are often associated with hot water and/or steam. These gases can escape into the atmosphere accidentally, or during testing and bleeding activity.

Post-lease and development impacts can be somewhat greater than those encountered during the pre-lease period. Increased drilling could increase the amount of noxious gases and particulate matter introduced into the air.

The production phase would be the time of greatest activity in a geothermal field. Particulate matter and noxious gases would increase. Vehicles and machinery would continue to release particulate matter and noxious gases into the air during construction activities.

Long-term air pollution may come from production wells and power plants. Steam and non-condensible gases may be released into the atmosphere in dry steam systems. During down periods for repairs, steam and associated non-condensible gases may be vented into the atmosphere before reaching the plant.

Hydrogen sulfide is the dominant non-condensible gas released into the atmosphere at the Geysers. Other non-condensible gases are NH3, CO2, N and H. This may cause air pollution. Methods are being tested in the Geysers to prevent gases, especially, hydrogen sulfide, from escaping into the atmosphere. Non-condensible gases may be introduced into the air from the power plant and evaporating ponds.

Radiological contaminants and non-ionizing radiation may become environmental problems. Radiological isotopes are used as tracers and introduced into the reinjection wells at the Geysers to study the reservoir characteristics.

None of these isotopes have been recovered as yet. If they circulate through the reservoir, and escape into the atmosphere, from the production wells, before the isotopes decay or can be recovered, radioactive particles may come in contact with living things.

Non-ionizing radiation may present a problem if a number of high voltage lines (500 kv or greater) are required. This radiation may dwarf plant species or cause discomfort to those people and animals that are in close association with the power line.

Air pollution should markedly decrease when all activities cease. Particulate matter (dust) may remain a problem from disturbed areas.

b. Possible Mitigating or Enhancing Measures

Monitoring of dust should be done by site inspection of construction and road usage during the dry season. If excessive dust is generated, oiling or watering of roads would be required. Hydrogen sulfide should be oxidized before it is permitted to escape into the atmosphere. This applies to all testing and venting activities. Wherever possible, steam and condensible gases should be condensed instead of being released into the atmosphere (GRO Order No. 4, Section 9.A.3).

High kilovolt power lines should be located in such a way, or isolated in such a manner, to minimize the effects of non-ionizing radiation. Frequent testing should be carried out for the atmospheric presence of radiological isotopes. Should these substances be discovered, use of such compounds would be discontinued.

c. Recommendations for Mitigation or Enhancement

Recommendations for mitigation or enhancement are found in Appendix D as stipulations.

d. Residual Impacts

Air in, and adjacent to developed areas, would contain noncondensible gases released from the geothermal reservoirs, engine exhaust emissions, and fugitive dust.

Air quality standards may occasionally be exceeded, particularly during periods of temperature inversion. The cumulative effects of discharging noncondensible gases to the atmosphere during the period of production are unknown and may remain for future generations.

Noise levels would increase in developed areas during the life of the field. The strongest unavoidable impacts on the increased noise level would occur during drilling and field development operations.

2. Soils

a. Anticipated Impacts

Impacts due to erosion would be greatest in areas where the vegetation is disturbed or destroyed. Use of off-road vehicles (ORVs) in the geothermal area would cause soil compaction. This disturbance would start in pre-lease exploration and increase during post-lease exploration, development, and production programs. In general, as these programs develop, the soil would become more and more impacted. Some unimproved roads would be graded in order to move equipment to drill sites. Grading would destroy soil structure; it might also loosen soil in certain areas and compact it in others. Loose soil often leads to an increase in soil erosion in selected locations; while in other locations compacted soil decreases water infiltration and increases runoff and soil erosion.

The establishment of a drill pad requires the removal of a strip of vegetation approximately 650 square feet (29 square meters). Exposure of the soil by removal of vegetation would promote increasing erosion. Oil spills from drilling rigs or vehicles could contribute to soil pollution. Alteration of soil depth and structure would result from the construction of pits to hold water or drilling mud. Some damage would occur to soil where pipelines and transmission lines are constructed. Removal of vegetation for the construction of such features would allow for increasing amounts of erosion.

Construction of small structures would also alter soil characteristics. The soil would become mixed. If carefully done, such construction should have little effect on soil erosion. If power plant construction occurs, an area of approximately 5 acres (2 hectares) would be cleared and leveled. This soil would be exposed to erosion and compaction. Removal of surface installations would disturb soils and vegetation.

b. Possible Mitigating or Enhancing Measures

During pre-lease and post-lease explorations, ORV travel should be restricted as much as possible. Where this travel is absolutely necessary, it should be conducted in such a manner as to minimize damage to vegetation and to soil structure. Travel should not be up and down the slope, but approximately on the contour.

The maintenance and grading of unimproved roads should be carried out so as to hold water on the land rather than to promote runoff.

In construction operation, whenever possible, top soil should be stockpiled and replaced. Subsoil exposure should be avoided. Where possible, mulch and uprooted vegetation should be left to remain upon the soil surface. Large oil spills should be removed and the residue should be incorporated into the surface soil over a wide area.

c. Recommendations for Mitigation or Enhancement

Recommendations for mitigation or enhancement are found in Appendix D as stipulations.

d. Residual Impacts

Topsoil would be lost for the duration of use beneath roads, wells, disposal ponds, power plants, and other structures. Soil depth and structural changes would be permanent on many developed sites. Some soil losses would be experienced due to increases in wind and water erosion during surface disturbance activities. The accumulation of toxic elements in the soil is possible, but remains an unknown residual impact due to the lack of research information.

3. Geology

a. Anticipated Impacts

Geothermal development could bring about changes in seismicity and cause landslides and subsidence. Potentially unstable materials in the area may affect the design of roads and foundations. The Rio Grande Rift is prone to natural seismicity. A survey of earthquake records indicates the daily occurrence of micro-earthquakes in the immediate vicinity of this area. Earthquakes of medium magnitude have been recorded within the last 200 years. In addition to natural seismicity, the possibility exists of inducing seismic activity along faults by fluid injection in or near fault zones during geothermal development. The potential for such impacts are unknown and no assumptions can be made now.

The danger of landslides in the area is considered to be low in most of the project area; however, along the flanks of mountains, in the area where massive lava flows overlie pyroclastic materials, landslides could result from careless construction practices. The occurrence of pyroclastic materials may also lead to unstable foundation conditions for drill structures and power plants. Pyroclastic materials frequently alter to montmorillonite, which exhibits thixotropic and swelling properties. Because of these properties, the undetected occurrence of montmorillonite in foundation materials could cause deformation of overlying roads or structures as well as building foundations.

Subsidence is a danger in geothermal development that results from extraction of fluids from the ground, and compaction of sediments in and overlying the fluid reservoir. Reliable predictions cannot be made for a specific area until it has been thoroughly explored. Factors affecting subsidence include: 1) the geologic structure of the underground reservoir, 2) the compressibility of rocks which yield fluids, and 3) the change in pressure that occurs as fluid is withdrawn.

Renewed volcanism is a possibility which cannot be entirely dismissed. However, the likelihood of renewed volcanic activity within the expected lifespan of any geothermal development is sufficiently small to be an acceptable risk if the area is monitored by seismometers and tilt meters.

Exploratory drilling in the proposed area would reveal scientific knowledge about the subsurface geology of a largely unknown area. With each new geothermal development, new data is gathered and new technologies developed so that the potential for adverse impacts such as induced seismicity or subsidence is lessened.

b. Possible Mitigating or Enhancing Measures

Numerous mitigating measures as well as those with implication to prevention and control of induced seismicity, subsidence, landslides, and unstable foundation materials are contained in Parts 270.34(b), 270.37, 270.43, 270.48, 270.76 and 3204.1(e) of the Code of Federal Regulations. GRO Order No. 4, "General Environmental Protection Requirements", in itself (Appendix F), serves as partial mitigation.

Prevention of subsidence and induced seismicity is not assured in geothermal operations. Prevention measures such as various monitoring methods, as described in GRO Order No. 4, are prescribed to detect minute earth movements which would forewarn of larger more damaging movements. Some mitigating measures which can be used by the USGS and BLM, if subsidence is detected, include reduced production, increased injection of fluids, and in the most severe cases, suspension of production.

If, during the preconstruction examination, a location is identified as a potential landslide area, BLM and USGS would not approve the project plans until they are satisfied that the danger of a landslide no longer exists.

Standard geotechnical studies would be done to identify the properties of the ground beneath proposed construction sites. No construction would be allowed until BLM and USGS are satisfied that there is no possibility of collapses due to an unstable foundation.

GRO Order No. 4 requires that proper consideration be given to potential hazards in all Operating Plans submitted to the USGS for approval. In some instances, detailed preconstruction exploration and testing could be required. The degree of prior examination would depend on the type of construction and the degree of existing soil and geologic data. When hazards are found or known to exist, proper design by competent professionals is required.

c. Recommendations for Mitigation or Enhancement

Recommendations for mitigation or enhancement are found in Appendix D as stipulations.

d. Residual Impacts

The major impacts which cannot be avoided are mostly related to the extraction of the subsurface geothermal resource. Drilling and related soil and substrata material displacement would result in some degree of adverse residual impact. The degree and full extent are unknown now. Precautions and mitigating measures should alleviate the potential for such problems as subsidence and induced seismicity.

The long-term impacts of geothermal resource extraction cannot be predicted or rated now. Should subsidence or seismicity occur, significant alteration of the landscape is possible. Little is known of technological capabilities or improvements which may be developed to avoid or minimize such impacts.

4. Water

a. Anticipated Impacts

Pre-lease exploration and post-lease explorations should have little effect upon surface water or groundwater quality. However, as drilling proceeds, the possibility of groundwater pollution could increase. Pollution could be caused by drilling muds, saline water, or otherwise contaminated water. As production continues, groundwater withdrawal could lead to subsidence of the geothermal area. The lowering of the water table is possible. There is a possibility for an accidental blow out.

b. Possible Mitigating or Enhancing Measures

Drilling muds, saline water and other contaminates should be kept out of the groundwater supply (GRO Orders Nos. 1 and 2). Subsidence of the geothermal area can be prevented by maintaining the water table through fluid injection (GRO Order No. 4, Section 8). Water quality of geothermal wells must be monitored and, if not up to the required State or Federal standards, appropriate measures must be taken (GRO Order No. 4, Section 10). Blowout protection measures would be applied to all wells (GRO Order No. 2, Section 2).

c. Recommendations for Mitigation or Enhancement

Recommendations for mitigation or enhancement are found in Appendix D as stipulations.

d. Residual Impacts

Groundwaters - If increased seismic activity occurred, well and spring discharges may change adversely. Variables affecting this phenomenon include depth of charge, size of charge, geologic structure, kinds of parent material, and proximity of activity to the water sources. There is a possibility of physical damage to an aquifer due to blasting. Should this actually occur, it would represent an adverse effect that would be virtually impossible to rectify by measures.

The hydrologic regime may be significantly disrupted, in some cases, permanently affecting to some degree local water supplies. In some instances, there may be local contamination of fresh water aquifers by saline groundwater. The potential exists for continuous long-term loss of artesian pressure. Because of the required pre-development plans and application of these plans, these impacts are expected to be rare.

Reinjection of liquid wastes could result in aquifer contaminates over a long period of time. However, this technique of liquid waste disposal has proven successful at Jemez Springs in geothermal development being carried out by Union Oil of California. It is expected to provide an equally environmentally sound method of waste disposal in the Socorro Peak Geothermal Area.

Discharge characteristics of existing hot springs may change in areas of development. In some underground operations, drainage of good-quality water for aquifers in the vicinity of the geothermal operation is unavoidable. This can become a severe problem in arid or semi-arid areas where previous water users have no other available water source. The area affected by dewatering would be dependent on the depth of the drilling, the permeability of the aquifers affected, and the recharge characteristics of the aquifers. Contamination of usable aquifers, due to changed head relationships in aquifers resulting from dewatering, can also cause unmitigating impacts. Erosion and sedimentation of surface waters would occur from roads, drilling sites, trails, ORV travel, and test excavations.

Changes in natural surface drainage systems can cause unmitigable impacts on the drainage system below the geothermal operation. For example, settling out the sediment normally contributed by the upstream portion of the stream, or adding sediment-free water to the stream, can cause increased channel erosion below the geothermal operation.

Stream crossings would inevitably produce suspended sediments. The act of constructing adequate stream-crossing structures and fords would increase suspended sediment during the construction phase. Unexpected, or unusual peak flows may cause stream-crossing structures to fail. These climatic events may also cause pits to overflow and the contents to enter stream channels. Failure of earthworks that contain settling ponds during heavy rains may allow sediment or toxic material to reach streams, lakes, and marshes.

Surface Water - Water pollution from airborne oxides of sulfur and nitrogen cannot be totally avoided. Excessive water demands could lower water tables and drain small lakes or ponds or dry up small streams if the water comes from local sources. In arid areas all water sources may be critical to wildlife. Loss of these sources would destroy aquatic species and many terrestrial species. There could be some disturbance of stream beds, siltation from erosion of disturbed lands, and modification of local water levels even under the most stringent application of regulations. This would affect the aquatic habitat and fisheries resource. Most of these impacts would be temporary and local, but in some unforeseen situations, the habitat and fisheries loss might be permanent. Accidents during production may contribute additional sediment to streams and lakes. The long-term effects of excessive sedimentation are often more serious to aquatic plants.

Some sediment may be produced by all except airborne exploration activities. The sediment may adversely affect surface water quality. The amount of suspended sediment produced after mitigation from any one action on a specific area will vary with conditions.

Surface water quality is expected to be lowered temporarily due to accelerated erosion on disturbed sites.

5. Vegetation

a. Anticipated Impacts

Geothermal development, within the lease area, would have impacts on vegetation. Impacts would range from low to high on terrestrial vegetation, but would be negligible on aquatic vegetation because of its scarcity in the lease area. The pre-lease and post-lease exploration phases of geothermal development would have negligible to low impacts on the vegetation resources of the lease area.

Off-road vehicle travel and road construction would disturb vegetation. The extent of the damage depends on several factors including: 1) the type of vegetation involved (grass protects soil much better than a shrub; provides more groundcover; and recovers faster), 2) the amount of slope (areas with steep slopes are very unstable and unsuitable for roads), 3) the stability of the soil involved, and 4) the number, size, and frequency of travel over roads and trails. Off-road vehicle travel and road construction have negligible to low impacts during the exploration phase.

Shallow well drilling is expected to have low impacts on vegetation. Some vegetation is damaged or destroyed in the 100-square foot (9.29 square meters) area required for shallow well drilling activities.

The drilling of geological and exploration holes requires a level drill pad of 1 to 4 acres (0.4 to 1 hectare), and a sump of 2,400 square yards (2,000 square meters). Both the drill pad and sump are completely cleared of vegetation and are sometimes surfaced with oil or gravel. Impacts during this phase of development are low.

Impacts from the testing of a well would usually be low unless toxic substances escape into the environment and are absorbed by vegetation. The absorption of toxic substances by vegetation may inhibit or prevent growth and can poison livestock and wildlife.

Impacts during the development phase would be similar to those incurred during the exploration phase but of greater intensity. There would be an increase in the area disturbed by road, drill pad, and sump construction because of the increased number of wells drilled during this stage of development.

Production phase impacts would be similar to those encountered in the exploration and development phases but of even greater intensity. More roads, drill pads, and sumps would be constructed which will destroy an even greater amount of surface vegetation.

Vegetation would also be destroyed during the construction of necessary pipelines and power plants. Pipeline rights-of-way may be paralleled by maintenance roads, and both are usually cleared of vegetation. The typical power plant occupies from 2 to 5 acres (0.8 to 2 hectares). Vegetation is completely removed from the power plant site.

The hot water system, which may contain high concentrations of toxic elements (i.e., boron, sulfur), can have significant impacts on vegetation. Pipelines may leak, break or bleed off from wells, or other accidents may occur that introduce these toxic elements into the soil where they can be absorbed by vegetation.

Certain non-condensible gases may be released into the atmosphere. Hydrogen sulfide, carbon monoxide, and other gases, when absorbed by vegetation, may inhibit or prevent growth.

Transmission lines would be required to transport electricity from the power plants to areas of use. The construction of these lines would further disturb the vegetation within the power line corridor. Large vehicles are needed to transport and erect the materials needed in power line construction. Maintenance of the power line may necessitate the construction of a road which would further disturb vegetation.

In general, the construction of a power plant and associated pipelines, transmission lines, and roads have a high impact on vegetation. Vegetation would not be significantly impacted during close-out because these activities would be restricted to existing roads.

b. Possible Mitigating and Enhancing Measures

Surface disturbance caused by off-road vehicle use, road construction, drill pad construction, pipeline and power line rights-of-way can be mitigated by adhering to slope stability, erosion control and proper land use procedures as outlined in GRO Order No. 4, Section 5 and GRO Order No. 4, Section 2.

The effects of toxic substances on vegetation can be minimized by following the measures in GRO Order No. 4, Section 9 on pollution and waste disposal.

The lessee shall conduct his operation in such a manner so as to minimize effects on threatened and endangered plants. Proper procedures are outlined in GRO Order No. 4, Section 6.

Reclamation procedures, which, if successful, would enhance a disturbed area, can be found in GRO Order No. 4, Section 6.

c. Recommendations for Mitigation and Enhancement

Recommendations for mitigation or enhancement are found in Appendix D as stipulations.

d. Residual Impacts

Residual impacts are expected because of the difficulty in revegetating disturbed areas due to low precipitation and high evapotranspiration levels common to the Southwest. Severely eroded or compacted areas would be particularly hard to revegetate. Plants adopted to the lease area are hard to establish from seed, and in most cases, their seeds are in short supply. Below average rainfall years common to the lease area may compound the revegetation process. Since the success of a revegetation operation is highly site specific, it would be difficult to estimate the extent of residual impacts.

Accidents, such as broken pipelines, release toxic substances into the soil, which might inhibit or prevent growth for a number of years. Brines from geothermal wells may change the vegetative composition. In most cases, residual impacts resulting from accidents can be expected to be low in number and in overall effect on the environment.

6. Animals

a. Anticipated Impacts

(1) Pre-lease Exploration

The exploration operations phase of pre-lease exploration may result in temporary, local, and site specific impacts. It is anticipated that negative impacts of a low magnitude would occur except in areas where endangered species are involved. In these areas, high impacts may be expected.

The degree to which aquatic animals may be impacted would vary depending upon the proximity and duration of such activity to existing waters and adjacent shore lines. Aquatic animal life would be influenced by any changes in the availability of water and vegetation. Animals and birds which depend upon aquatic life for food may be influenced.

Vehicular travel, drilling operations, and other associated activities may cause some temporary displacement and harassment. If such activity were to occur during the nesting season, nests may be abandoned or destroyed and potential reproduction lost. Some species, such as the killdeer, are flexible in their habitat needs, and therefore, could find suitable habitat elsewhere within the assessment area.

Several areas of aquatic habitat have been identified as being occupied or used by endangered species, including: Mexican duck; olivacious cormorant, little blue heron, whooping crane, peregrine falcon, and osprey. Exploration, near the edges of these areas, could seriously jeopardize breeding, nesting, resting, and loafing activities of these species. The Mexican duck has been categorized as a relatively secretive species, unable to withstand prolonged disruption, and therefore, presumably requires extremely quiet conditions.

It is not expected that activities associated with geothermal activity would have a large impact on the olivaceous cormorant. Disturbance from geothermal activity is likely to be detrimental to the bald eagle at Elephant Butte Marsh during the period of November through February. With the information available, it is not known what impact geothermal activity would have on some of the other species present.

Low flying aircraft over the Bosque Refuge would cause a very large disturbance to all species present, including the endangered whooping crane. Geothermal activities such as venting, or when loud noises are involved, may have an impact on those species close to the perimeter of the Bosque Refuge.

The probability of significant detrimental impacts to terrestrial animals should be minor if such activity is confined to existing roads. Travel over undisturbed terrain can cause seriously harmful effects to some animal species. Any concentrated or long-term traffic may affect both breeding and nesting activities. Bird nests that are constructed in low growing shrubs, young birds, and species which have greatly reduced mobile abilities, may be disturbed or destroyed by surface vehicles traveling cross-country.

Off-road vehicular travel and drilling operations could result in the loss of valuable food and/or cover for various animal species. The magnitude and severity of such loss would depend upon the location of such activities and the relative importance of these areas to the sustenance of animal species occurring there, as well as the relative importance of the impacted species (e.g., game animal, endangered or threatened species, furbearer, etc.).

Intensive "active" seismic and drilling activity in WHA-IIIA, B, and C could cause serious impacts on antelope if the disturbance occurs during the dry summer months and/or during fawning (May and June). The use of stockwaters as a source of water for drilling operations could also seriously affect antelope and other animal species (aquatic and terrestrial), if the water hole is depleted and no other drinking source is available.

Pre-lease exploration within the Polvadera, Socorro, Magdalena, and Chupadera Mountains along the foothill areas of these mountains could result in low, temporary disturbances to associated animal species (e.g., mule deer, Gambel's and scaled quail). The construction of drainage crossings, or any drilling occurring within drainage bottoms, could result in the destruction of important habitat as well as the disturbance of the soil substrata, causing disruption and destruction of various soil dwelling organisms.

Within the Rio Grande Valley proper, moderate impacts upon terrestrial habitat and associated species may occur. The riparian areas identified, would receive the greatest impact. Such areas are extremely valuable to wildlife. During the exploration phase, local sites of riparian habitat could be altered substantially.

Exploration operations within WHA-II, III, and IV could result in the loss of a small amount of habitat in addition to the temporary displacement, harassment, and possible loss of animal life.

The band-tailed pigeon in Nogal Canyon south (T.9 S., R.4W.) and the prairie falcon and other raptors in San Lorenzo Canyon would be disturbed during this phase of the operation. Disturbance during nesting to the raptors in San Lorenzo Canyon could reduce the production of these species.

Throughout the assessment area, water is a highly limiting component for many animal species. Any alteration in the availability of this essential, life-sustaining component could result in devastating effects to associated, dependent animal life.

(2) Post-lease Exploration

Post-lease exploration would have a large impact upon wildlife. Impacts of the pre-lease exploration would intensify during post-lease exploration due to the increased activities and the larger equipment. The presence of a drill rig in an area for a number of days or weeks and the noise produced by it may disrupt breeding, nesting, or other activities of certain animals. Mud pits may be present and, due to the lack of water in this area, some wildlife species would use these pits as a source of drinking water. Usually, the water contains some oil products and, occasionally, chemicals used in drilling that may be toxic to animal life. These drill rigs operate 24 hours a day. Therefore, animals in the immediate area of the drill rig would be disturbed during the entire drilling operation. Some animals would become accustomed to the noise and activities.

(3) Development

A number of drill rigs would be active in the area once exploration indicates an economical geothermal resource. The increased number of drill rigs would intensify the problem of wildlife impacts, as discussed in post-lease exploration.

Pipelines would be constructed by clearing vegetation and traversing the land with vehicles. The lines are usually designed to cover the shortest distance possible; therefore, the line usually crosses roadless isolated lands. These activities would further disturb wildlife species. More dens and nests would be disturbed with vegetation removal and soil disturbances, both above and below ground. Some shooting of animals may take place for food or recreation.

Power plants also require the removal of vegetation and the leveling and compacting of soils. These activities further add to the impacts previously discussed.

Transmission lines would be constructed to carry power away from the power plants, although these transmission lines are now designed to virtually eliminate raptor electrocution. The towers provide excellent perches for birds of prey. Shooting of birds, as they are perched on these towers, remains a serious problem.

Roads would have a very large impact upon wildlife species. The increase in access would increase man's activities from both a working and recreational aspect. Areas that once were isolated would now be used by man and his machines. These activities may disturb breeding, nesting, resting, and associated activities. Some animals need isolation to produce their young or just carry on their everyday activities.

(4) Production

Construction of power plants or other facilities may take place. Because of permanent vegetative clearance at the sites of certain facilities, additional animal species and their habitat may be lost. The ultimate impacts, resulting from this phase, would depend upon the location of the activities associated with the development and production phases. Based upon available information, impacts of greatest significance would be associated with the springs at the base of Socorro Mountain, Elephant Butte Marsh, and Rio Grande Valley.

Immediate and cumulative impacts, associated with an increase in population, would have wide-ranging effects upon wildlife species and their habitat.

The impacts associated with increased human populations would not stop at the boundaries of the assessment area. Other areas exhibiting important and unique biota may also be affected. Remote areas of the Ladron, Magdalena, and the San Mateo Mountains may be frequented as the result of increased human pressures.

(5) Close-out

If close-out takes place, many localized areas may once again become isolated. Species that require isolation may again invade the available habitat.

b. Possible Mitigating or Enhancing Measures

The areas that are critical for the survival of some wildlife species would have to be protected. Habitat areas of particular interest include: 1) endangered and threatened species habitat, 2) wetland and riparian habitat, 3) antelope migration and/or seasonal movement routes, 4) antelope kidding grounds, 5) raptor nesting areas, and 6) brushy draws.

Geothermal activity adjacent to cliffs, lakes, reservoirs, small streams, marshes, springs and seeps may not be allowed. The discharge or leakage of effluent into wetland and riparian areas should be prevented. Sump pits may have to be protected to prevent death or injury to wildlife. A chemical analysis should be made in sump pits and other liquid effluent to determine the composition. Should these analyses indicate whether toxic or harmful substances are present, protective devices may be required on a case by case basis.

Surface disturbance could remove key vegetation species that are important to the survival/maintenance of wildlife individuals or populations. Therefore, the removal of vegetation species should be permitted only when absolutely necessary. The removal of the tree overstory when clearing a pad for drilling operations would be permitted, but kept to a minimum. The disturbed areas should be reseeded with a mixture of the key vegetative species as determined by the BLM authorized representative. In areas where vegetation is difficult to re-establish, reseeding disturbed sites would be required until the seeding is successful.

Power line electrocutions of large raptors such as eagles, red-tailed hawks, and other large hawks, in general, are limited to localized areas where these birds hunt and nest. Power lines erected in raptor hunting and nesting areas should conform to those described in USDA Rural Electrification Administration, REA Bulletin 61-10 for raptor protection. Fences, pipelines, or other barriers should be designed to allow seasonal antelope movement. There should be restrictions on surface disturbance and intrusions within antelope kidding grounds and a buffer area surrounding the kidding ground. A buffer zone, in which there would be no surface disturbance, should be established along the boundaries of the Elephant Butte Marsh and the Bosque del Apache Wildlife Refuge.

c. Recommendations for Mitigation or Enhancement

~~General stipulations 1 through 24 and site specific stipulation nos. 39 through 43, 45 through 52, 54, 62, and 66, in Appendix D, should be adopted.~~

Recommendation for mitigation or enhancement are found in Appendix D as stipulation

d. Residual Impacts

Any permanent loss of wildlife habitat due to the building of roads, pipelines, transmission lines, or energy plants would be an unavoidable adverse impact. Other impacts and degrees of impacts depend largely upon the extent, duration, and manner in which geothermal development might take place in an area. Previous sections concerning wildlife indicate the significant amount of important wildlife habitat throughout the entire project area. Obviously, any major development in these vital habitat areas would have adverse impacts on the species which use them. The extent of these impacts would, of course, depend upon the amount of alteration and encroachment upon the existing natural environment.

Some damage to aquatic resources would occur, the magnitude depending upon variables such as soil types, terrain, climatic conditions, and degree of development.

While most impacts on wildlife through the exploration phase can be reduced by implementation of mitigating measures, some mortality, displacement, and temporary habitat loss may be unavoidable.

Cross-country ORV travel, exploratory road, trail, and drill site construction, movement of exploration equipment, and test-trenching operations may cause dislocation of wildlife. These losses would be relatively insignificant depending upon the extent and duration of operations, and primarily involve bird nests, young birds, rabbits, burrowing rodents, reptiles, and invertebrates.

The impact on wildlife from geothermal development cannot be mitigated in the immediate area of the facilities during the life of the activity. During construction, the wildlife and wildlife habitat would be displaced or destroyed. Small sedentary animals are more prone to destruction, while larger animals such as some big-game species and predators would leave the area. Mitigation through habitat rehabilitation cannot be accomplished until the facilities are removed, usually after 30 to 40 years. Effects on some species may be permanent, depending upon the type of rehabilitation employed and the land uses after close-out.

The displacement of animals that are sensitive to man's activities cannot be mitigated until these activities cease.

Hazards to wildlife from roads, fences, trains, power lines, etc., cannot be completely mitigated. Construction of new roads, even with high engineering standards, has a residual impact on wildlife never fully erased. Some animals may be unavoidably killed despite efforts to reduce loss.

The hazards to aquatic life from sediment pollution cannot be completely mitigated. After the initial facility construction period, erosion control measures and revegetation of unused areas would decrease the accelerated erosion. Sediment loads from the original construction would already be moving downstream and sediment from road drainages, poorly revegetated areas and new construction activities would continue to cause some sediment pollution.

The long-term ecological effects of sedimentation of streams, ponds, and lakes are often of greater consequence to aquatic species than are immediate short-term effects of direct mortalities.

Natural surface waters such as springs, ponds, lakes, marshes, and streams along with their associated plant communities are vital to the survival of many aquatic and terrestrial wild animals.

Stream crossings or other activity that introduces suspended sediment into bodies of water which contain aquatic organisms is going to cause some damage to these populations. Leakage of toxic substances into these waters can occur through failure of containment structures. Damage to aquatic populations may occur through the discharge of hot water into a body of water even though the discharge may otherwise be of good chemical and physical quality.

Animal populations displaced or destroyed can usually be replaced from populations in the surrounding ranges provided the habitat is eventually restored. If a threatened or endangered species is involved, however, the loss may be a permanent unmitigable impact.

In some instances, it may be impossible to completely mitigate secondary impacts upon contiguous resident populations and habitats. Animals displaced from home ranges may be forced to use adjacent areas already stocked in carrying capacity. The resulting degradation of the adjacent habitats, the forced interactions with the resident animals, and potentially greater losses to the original populations involved are seldom subject to more than token mitigation.

Changes in access patterns in a region would have definite impacts on man's use of game and fish species. Game and game-fish would be subjected to increased exploitation pressures in general. Local and easily accessible populations may be excessively exploited. Large areas around industrial complexes may be restricted to hunting and fishing. These considerations can be mitigated only to limited degrees by more intensive management of wildlife and wildlife habitat. It can become necessary to reduce big game, predator or "nuisance" animal populations displaced by human activities to prevent overuse of remaining habitats and conflicts with other human uses.

The immediate impacts of relatively small terrestrial habitat losses cannot be mitigated. Rehabilitation of sites damaged by ORV use and earthmoving activities would mitigate the long-term effects. If roads and trails are not closed to public use during and after rehabilitation, habitat damage may be relatively permanent.

7. Landscape Character

a. Anticipated Impacts

(1) Open Space and Visual Resources

The amount of potential visual impact can be directly related to the degree that any landscape alteration and development would contrast with and deviate from the existing landscape character. Some deviations can have positive visual results only if the introduced elements borrow or complement forms, lines, colors, and textures found in the existing natural landscape.

Briefly, form in the landscape can be characterized by geometric shapes such as the pyramid form of a mountain peak (Socorro Peak) or the flat horizontal form of a plateau (La Jencia Plains). If structural forms introduced by man's development repeat similar forms, as found in the landscape where they are to be placed, contrast would be minimized. The opposite holds true; if for example, a tall vertical structural form is placed on a flat, horizontal land plane, then, form contrast would be maximized.

Line in the landscape can be found in the silhouetted ridge of hills and escarpment (Quebradas Hills) or the linear pattern of a stream (Rio Grande). Line is, generally, seen as a result in color and textural contrast of the cleared surface to the surrounding vegetation. If lines introduced by man's development such as roads, power lines, etc., repeat similar linear patterns, overall line contrast would be minimal. However, linear development such as pipelines, roads, etc., that do not follow a naturally established line, would add undesired visual line contrast.

Color in the landscape is found in all naturally established features such as vegetation (creosotebush, alkali sacaton), geology (Black Mesa), soils (Rio Grande Breaks), etc. Many times, the potential contrast of man's structural forms and linear facilities can easily be reduced if they are similar in color to the dominant natural color of a particular landscape involved.

Texture in the landscape ranges from coarse to medium in the trees (pinyon-juniper) and craggy rock outcroppings (Jornada Lava Flow), to fine and smooth on the surface of bare land (Jornada Plains) or water bodies (Elephant Butte Marsh). A smooth structure would introduce contrast in texture if placed within a natural setting which contains coarse textures. However, a similar smooth structure would reveal little textural contrast if it were placed among smooth textured grass-covered terrain.

Some landscapes are capable of absorbing or screening modifications much better than others, simply because the combined lay of the land and vegetative type patterns are more favorable. This concept is based on the premise that a combined degree of textural variety and terrain variety, as well as the height of existing vegetation, would dictate the overall ability of a particular landscape to absorb modification.

The overall visual impact of geothermal development would vary according to size and extent of the developments associated with each phase, and the visual resource objectives they must meet. The Socorro Peak leasing area contains Class II, III, and IV visual resources. All Class II visual resources would be exempt from geothermal development due to their sensitive nature. Special consideration would be given to the Class III corridor paralleling I-25 north and south.

Pre-lease exploration using active seismic methods and the drilling of shallow temperature holes, would have a temporary detrimental effect on the open space and visual resource values of the landscape. The low level intensity of surface disturbance during this phase would create intrusions of a temporary nature. The most significant visual impacts would result from repetitive ORV use by heavy equipment, the clearing of small drill pads, and the construction of temporary access roads.

Post-lease exploration uses many of the methods and equipment common to pre-lease exploration; however, this form of exploration is of a more intensive nature. Man-made intrusions of roads, drill pads, sump pits, and machinery are larger in scale and occupy the terrain for longer periods. The open space values of the landscape would be invaded by tall drilling rigs, heavy equipment, and structures associated with this intensive phase of exploration. The visual resources would suffer adverse impacts. Many of these would be of a transitory nature. Soil and vegetative disturbance would produce visual scars which may be healed by time and rehabilitation measures; dust and gaseous discharges would intermittently interrupt scenic vistas and natural landscape patterns. After testing is completed on an exploratory well, a series of valves would remain. Resembling a mechanical "Christmas tree", these valves would create a negative visual impact on the natural landscape.

The development phase would have, essentially, the same type of intrusions that occur in post-leasing, but would be of a greater magnitude and more permanent in nature. Additional visual impacts would result from the above ground network of pipelines, generation plants, cooling towers, and transmission lines. Surface disturbance and accompanying visual impacts would be intensified over a larger area, and for a substantially longer period. Open space qualities and aesthetics would be adversely affected on a more or less permanent basis, considering the minimum life of a geothermal plant is 30 years.

During the production phase, visual impacts would not experience any significant increase over those incurred during the development phase. Replacement well drilling and evaporation ponds would not add to an environment already disturbed by similar intrusions. If well spacing is decreased to one well per 20 acres (8.09 hectares) in order to maintain production capabilities, the visual impacts will be of a greater intensity. The visual environment would be intermittently obscured by escaping steam from production wells and water vapor clouds emitted from cooling towers.

During close-out, the impacts of field abandonment are related to the use of heavy equipment similar to that used in initial construction and field development. Close-out operations, involving removal of improvements and restoration of the surface, would have temporary impacts related to large areas of raw earth being exposed, shaped, and rehabilitated.

(2) Primitive Values

An area relatively free of man-made intrusions, having 5,000 or more acres (2,023 hectares) of highly scenic or uniquely ecological resources, is considered to be primitive in character. Three wilderness areas within the Bosque del Apache Wildlife Refuge, outside the leasing area, possess these values. In addition, the Southern Malpais Lava Flow has been selected for a primitive area study.

Every phase of geothermal development would adversely affect the primitive values of an area; beginning with ORV travel of pre-lease exploration and building, to a peak of maximum disturbance during the field development and production phases. The solitude would be shattered by noises emanating from all types of vehicles. Well testing and venting may produce varying degrees of noise. The mere presence of roads, drilling rigs, and machinery within an area would essentially negate any existing primitive values. The more intensive phases of geothermal development would not have any additional significant impacts on primitive values. These values would have been compromised earlier by initial geothermal activities.

b. Possible Mitigating and Enhancing Measures

(1) Open Space and Visual Resources

For geothermal developments on Federal lands, full consideration must be given to aesthetic design and placement of man-made structures. Use of compatible colors, textures, forms and lines is necessary to minimize the visual impacts. Landscaping, vegetative restoration, and rehabilitation of landforms would be required to soften the impacts of man's activities. Comprehensive site planning, beginning with the earliest stages of the geothermal leasing program and continuing through full-scale operations, can contribute greatly to harmonious layout and design, best suited to the natural landscape character.

Site location and associated developments would be required to be compatible with the BLM's planning documents as well as existing local and regional land use planning.

Geothermal exploration and development would be required to avoid those areas where restriction of such activities is recommended and dictated by the combined criteria of: 1) visual resource class, and 2) the ability of the landscape to absorb modification.

Geothermal developments should be located to avoid or to maintain a reasonable distance from major focal points or dominant features in the landscape. Man-made developments should not overwhelm the natural character of the land.

Geothermal developers would be required to take aesthetics into account during planning, design, and construction of facilities. Any architectural design, physical layout, construction, and development stipulations should be identified. The geothermal developer should be required to carry them out accordingly.

Provisions would be required, to the extent practicable, that all structural facilities be designed to meet existing local standards and cultural styles.

The facilities, individually and combined, would be designed to hide or blend harmoniously with the particular surrounding environment.

All improvements would be located to the extent feasible on the existing contours. Exposed slopes and disturbed areas would be revegetated. Scars which cannot be fully rehabilitated would be screened through the use of plantings and other native materials.

c. Recommendations for Mitigation or Enhancement

Recommendations for mitigation or enhancement are found in Appendix D as stipulations.

d. Residual Impacts

The alteration of a natural environment into an industrial development would have definite adverse impacts which cannot be mitigated. Structures, roads, power plants, transmission lines, and pipelines all present degrees of unmitigated impacts. These intrusions would present a lasting impairment to the visual quality and natural setting. The degree of impact would depend on the design, location, and many other factors. The loss of vegetation, soil, and visual quality would continue in varying degrees for the life of the geothermal project. Landforms and the natural character of an area would never regain their original properties, and therefore, some form of permanent alteration would persist.

8. Land Uses

a. Grazing

(1) Anticipated Impacts

Grazing use, during the exploration phase, would be lightly impacted due to losses in vegetation by road and drill pad construction. Broken fences and/or gates left open, that occur in the process of exploration, could cause livestock straying.

During development, an increase in construction activities would disturb even more vegetation during this phase. This would result in further livestock forage losses.

Impacts on grazing use would continue during the production phase as more vegetation would be displaced by the construction of roads, drilling pads, pipeline and transmission line corridors, generating, and other related facilities. Each of these reduces livestock forage and may interfere with livestock movements.

Noise, associated with testing a well, may disrupt livestock movements. Noxious gases and fluids released during drilling may interfere with livestock movements and may cause poisoning if suitable concentrations of these toxic materials collect in livestock forage.

Adverse impacts during the abandonment of a geothermal field would decrease as toxic emissions decreased and activity in an area declined. As disturbed areas are rehabilitated, forage production may slowly increase.

(2) Possible Mitigating or Enhancing Measures

Surface disturbance can be minimized by using existing roads, denying entry upon certain environmentally fragile land areas, and designing operations to have a minimal effect on erosion and natural drainages. Mitigating measures are outlined in GRO Order No. 4, Sections 2 and 5.

Protection of livestock from hazardous geothermal activities may be accomplished by fencing of hazardous areas to restrict livestock use. Proper procedures are outlined in GRO Order No. 4, Section 3. Livestock poisoning may be prevented by complying with the standards found in GRO Order No. 4, Sections 9 and 10 on water quality, pollution, and waste disposal.

Noise, which can stress livestock and limit their movements, can be minimized by complying with the procedures outlined in GRO Order No. 4, Section 11.

Geothermal activities shall not unduly interfere with the grazing lessee or his operation. Measures to minimize interference with other lessees are outlined in GRO Order No. 4, Section 2, on Land Use and Reclamation.

(3) Recommendations for Mitigation and Enhancement of Environmental Impacts

Recommendations for mitigation or enhancement are found in Appendix D as stipulations.

(4) Residual Impacts

Residual impacts are expected because of the difficulty involved in revegetating disturbed areas (see Residual Impacts - Vegetation). Disturbed areas that can be successfully revegetated would be restricted for grazing for at least 3 years to allow seedling establishment. Those areas that cannot be revegetated would represent a permanent loss in livestock forage.

Occasional accidental disturbance to livestock is to be expected. For example, an unexpected blowout may cause land, water or noise pollution which may disturb or displace livestock. Accidents are rare but nevertheless represent a possible residual impact.

b. Rights-of-Way

(1) Anticipated Impacts

Pre-lease and Post-lease Exploration - Rights-of-way now in use would probably not be impacted.

Development - Rights-of-way now present would not be adversely affected because they would have a prior right; but future rights-of-way would require some route adjustments if in conflict with development activities.

Production - Present rights-of-way in the production phase would probably be crossed by power transmission lines carrying power from the generators to the consuming areas. The present rights-of-way have prior rights that should be protected. There would, undoubtedly, be additional adverse impacts similar to those of major power line operation of the 345 kv class from the new lines.

Close-out - The removal of pipelines, power transmission lines, and roads would eliminate conflicts with other rights-of-way.

(2) Possible Mitigating or Enhancing Measures

Permits, or rights-of-way, will be necessary before pipelines, transmission lines, roads, power plants, etc., can be constructed on National Resource Lands. Environmental Assessment Records (EARs) will be written for each project by the BLM before any activity begins. Mitigating measures in the form of stipulations will be attached to each permit or right-of-way.

(3) Recommendations for Mitigation or Enhancement

Specific recommendations for mitigating and enhancing measures will be part of the EAR for each individual action.

(4) Residual Impacts

Residual impacts on rights-of-way should not be significant.

c. Urban and Suburban

(1) Anticipated Impacts

Pre-lease and Post-lease Exploration Phase - Urban and suburban areas would benefit from new jobs and information gained regarding possible new city water sources.

Development Phase - This phase would provide employment to residents and generate additional money into the communities. If sufficient supplies of hot water for home and industrial use are found, communities would be benefited.

If development occurs at a fast rate and with great intensity, considerable social stress would result. There presently exists a housing shortage in the area, and this problem would increase in a "boom" situation. Public services such as sewers, hospitals, etc., and schools would have problems meeting the rapid increase in demand. These and related increases in demand and social stress would result in inflation, increased crime rate, etc.

Production Phase - The populated areas would benefit from employment opportunities and possibly from lower cost electricity for homes and businesses. If the wells and production facilities are near communities, adverse impacts from noise and nauseous air vectors may be present. The county tax base would increase. Rapid population growth would lead to social stresses and problems similar to those discussed in the preceding paragraph.

Close-out - This phase has the potential to cause a major impact on the communities. A gradual or rapid close-out would cause loss of jobs, more expensive electric power, and loss of county tax base. There would be a decrease in population that would impact the housing and realty industries. House values would lower, and there would be problems in finding home buyers. There would also be some adjustments in public services, schools, etc., as the demand for these services decreases. Populated areas would benefit from the elimination of objectionable sounds and odors.

(2) Possible Mitigating or Enhancing Measures

GRO Order No. 4 discusses the lessee's responsibility for noise abatement. A more in-depth study would be necessary to identify specific mitigating measures to counter the adverse impacts on the population as a result of rapid and intense development and production.

(3) Recommendations for Mitigation or Enhancement

Recommendations for mitigation or enhancement are found in Appendix D as stipulations.

(4) Residual Impacts

There would be a loss of jobs by residents as the field is closed out. A new source of water may supply the urban and suburban areas. Consumers of the geothermally produced electricity would have to look for another source of power. Houses and buildings, abandoned as a result of close-out, would be visible for many years. The adverse effect on the housing market would be long-term.

d. Recreation

(1) Anticipated Impacts

All stages of geothermal leasing would have some direct impacts on dispersed recreation and indirect impacts on developed recreation areas such as the Bosque del Apache Wildlife Refuge. However, power plant and power line construction and the operation stages of development, would have the greatest impact on the recreation resources of an area. Additional intrusions of steam, noise, and odors would detract from most dispersed recreation experiences for several miles beyond any proposed geothermal plant.

Recreation uses such as hunting, fishing, hiking, sightseeing and collecting would receive greater impacts in areas where they occur more frequently. Large land areas now open to dispersed recreation activities such as ORV use, hunting and sightseeing, would be closed or restricted by the presence of roads, structures, and other geothermal developments. Geothermal exploration and development activities would necessarily restrict recreation use, to minimize public hazard.

Degradation of the recreation resources by geothermal developments in one area may cause increased pressure on other areas. This could cause overcrowding and accelerated resource deterioration, thereby decreasing the recreational experience.

A geothermal development can be a replacement rather than a displacement of recreation. As a recreation attraction, the geothermal development could include a visitor center and interpretive services. Swimming ponds, fishing, and boating activities could be possibilities, depending on the type of geothermal development.

(2) Possible Mitigating or Enhancing Measures

Identify those combinations and intensities of recreation resources that are most valuable and significant to future recreation needs. The national as well as local perspective should be incorporated. Such areas should be avoided and alternate sites for geothermal development selected.

There are several high-value recreation potentials that may be derived from geothermal development such as a visitor center and other recreation oriented activities. Identify and integrate these recreation possibilities with the existing recreation resources. This will allow for some form of replacement of recreation use rather than total displacement.

Restrict or control recreation uses to a minimum during geothermal activities to ensure safety of the public. At the same time, do not interrupt and reduce recreation needs and desires beyond what is necessary for public safety.

(3) Recommendations for Mitigation or Enhancement

Recommendations for mitigation or enhancement are found in Appendix D as stipulations.

(4) Residual Impacts

The loss or modification of recreation use would be dependent on the degree of geothermal development. The initial exploratory stages involving road construction and other forms of surface disturbance would affect existing recreation use. Loss of wildlife habitat, soils and vegetation would have long lasting impacts on hunting, sightseeing, and other forms of recreation. These impacts would be of greater intensity and length as the degree of geothermal development increases.

A producing geothermal development is estimated to have a minimum life of 30 years and can last for hundreds of years. The loss of traditional recreation uses for all practical purposes, would be of a permanent nature. Rehabilitation would take 10 to 20 years after abandonment. Total recovery of the resources would be impossible, and permanent impacts form of changed recreation patterns and altered landscapes would remain.

Roads constructed and used during various phases of geothermal development could provide access for recreational use to areas previously inaccessible.

9. Cultural Resources

a. Anticipated Impacts

A survey of cultural resources in the geothermal area will take place in the next few months. The study will involve intensive surveys of randomly selected land units within stratified environmental zones. The data obtained will enable the BLM to statistically estimate the site density and type(s) within an area.

This information will enable BLM to more specifically predict impacts on cultural resources. For example, the surveys should indicate areas of high and low site density. Generally, the impacts of all surface disturbing actions will be greater in the high density area. "Density" does not necessarily mean "significance." Sites in a low density area may be very significant because of their scarcity.

Also, a high density area with several site types is more likely to suffer greater loss of information through individual site destruction than another high density area with a single site type of low cultural complexity.

Pre-lease Exploration Phase - Airborne exploration would have no impact on cultural resources. Exploration techniques involving off-road vehicular travel, such as seismic and drilling operations and road construction, have the potential for partial or complete destruction of cultural properties. Roads and trails can have an indirect impact by increasing the vandalism at previously inaccessible cultural properties. All surface-disturbing activities have the potential of altering the natural and cultural context of properties in their vicinity.

Post-lease Exploration Phase - Construction of roads and drill pads has the potential for partial or complete destruction of cultural properties. The impacts of actual drilling would be negligible since most of the disturbance would have occurred during drill pad construction. Testing, venting, and close-out would have no impact on cultural properties.

Development Phase - Development wells and associated roads and pipelines all have the potential for partial or complete destruction of cultural properties. The extent of disruption of the natural and cultural context of the development area is greater than that associated with the exploration. Construction of power plants has the potential for partial or complete destruction of cultural resources as well as representing a marked intrusion into the natural and historic setting of nearby cultural properties. Transmission lines may have sufficient flexibility to avoid the partial or complete destruction of cultural resources; their presence in the vicinity of a cultural property would, however, constitute an intrusion on the natural and cultural setting.

Production Phase - No direct impacts on cultural resources can be anticipated for the production phase. Maintenance and repair activities may result in increased vandalism to cultural properties in the vicinity of the developed field.

Close-Out Phase - Close-out activities should have no adverse impacts due to additional surface disturbance. The removal of visible facilities can be considered as potentially beneficial in that it may re-establish the natural and cultural setting of cultural properties in the vicinity of the abandoned geothermal field. Closure of roads may reduce the potential for indirect impacts due to vandalism.

b. Possible Mitigating or Enhancing Measures

Possible mitigating measures may include: 1) avoidance of the resource, 2) recordation, 3) surface collection, 4) subsurface testing, and 5) excavation.

To avoid destruction of cultural resources, prior to surface disturbing activities, an archaeologist approved by the BLM, shall conduct a survey of cultural resources on the land to be disturbed or occupied. The survey shall meet BLM archaeological specifications. A survey for cultural resources shall not be required for land units that have been intensively surveyed as a result of previous studies.

In areas where avoidance of a site is not feasible as a mitigating measure, research designs and salvage of the site would be required. If archaeological materials are encountered during surface disturbing activities, operations would cease. The BLM District Manager would be notified, and operations would not continue until approval to proceed is granted (GRO Order No. 4, Section 7).

The preservation, restoration, maintenance, and nomination of all resources for the purposes of the National Register of Historic Places shall be in accordance with the provisions of Executive Order 11593 (36 FR 8921) entitled, "Protection and Enhancement of the Cultural Environment," or any amendments thereto (GRO Order No. 4, Section 7).

The following cultural resources, which are known to exist in the area of the proposed action, should be excluded from surface disturbance: Johnson Hill Pueblo, Bell Mountain Site, AR-NM-02-205, and AR-NM-02-348.

c. Recommendations for Mitigation or Enhancement

General stipulations 1 through 24 and site specific stipulation nos. 60 and 62, in Appendix D, should be adopted.

d. Residual Impacts

All excavations performed as "salvage" would result in a premature commitment of the resource. Salvage excavations develop, not as a rational plan within the scientific community, but as a last resort against the potential total loss of information at impacted sites. Although research designs are required for salvage work, the hurried excavation cannot exploit the information at a site as fully as would occur from work conducted at the initiative of the scientific community.

Once a site is discovered, even if not disturbed by geothermal resource development, residual impacts occur. Sites would become accessible to pothunters. Cultural resources are irreplaceable, and damage is done when they are disturbed in any manner. Abandonment still leaves the area accessible; and in some areas, pothunter traffic would increase as a result of greater accessibility and less human presence. Patrolling may reduce the impact of vandalism and pothunting. However, the area of the proposed action is too large to allow all cultural resources to be effectively patrolled.

10. Other Considerations

a. Anticipated Impacts

Anticipated impacts on educational, scientific, and other values would generally be minimal. The New Mexico Bureau of Mines and New Mexico Tech would benefit from new knowledge gained as a result of geothermal activity. However, if there is a rapid and large population growth during the development and production phases, New Mexico Tech may face problems of a greater demand for classes, rooms, etc.

Geothermal activity would have negligible effects on Langmuir Laboratory. If the activity produces steam clouds, the clouds may be either negative or positive to the studies that are going on at the time.

Geothermal activity would have no impact on the White Sands Missile Range. But the WSMR would have some impact by requiring the evacuation of all personnel in extension areas on firing days. There is also the remote possibility of geothermal facilities being damaged as a result of missile misfirings.

Impacts on the Bosque del Apache Wildlife Refuge and Elephant Butte Marsh are addressed in the wildlife section.

Geothermal activity would prevent other mining developments in the immediate area of geothermal facilities until after complete close-out.

b. Possible Mitigating or Enhancing Measures

To protect geothermal personnel in the WSMR extension area, they should be required to evacuate the area during firing periods. Due to various factors, such as other government agency responsibility, non-BLM jurisdiction of land, etc., other recommendations cannot be made.

c. Recommendations for Mitigation or Enhancement

Recommendations for mitigation or enhancement are found in Appendix D as stipulations.

d. Residual Impacts

A population increase, as a result of geothermal activity, would cause a greater demand for New Mexico Tech facilities.

There would still be the remote possibility of geothermal facilities being damaged as a result of missile misfirings. Also, geothermal activity would continue to prevent other mining development in the immediate area of geothermal facilities until after close-out.

B. Relationship Between Short-Term Use and Long-Term Productivity (After USDI, Final Environmental Statement for the Geothermal Leasing Program 1973)

The leasing of lands for geothermal resource development involves the commitment of a portion of the geothermal heat, water, and related land areas and resources of the sites involved. It is particularly significant to recognize that the geothermal heat is a wasting resource that, otherwise, would be dissipated over time from the surface of the earth to the atmosphere with little or no identifiable benefit. By contrast, development of this resource in an environmentally acceptable manner, can have substantial benefit by affording a relatively clean power generation energy source.

The exploration and testing phases of geothermal leasing are designed to determine the nature and extent of geothermal resources. Generally, the active portion of this phase is of short duration, sometimes extending only over a period of days, months or, at most, a few years. It may be intensive and continuous for short periods or periodic over several years. Where such exploration proves unsuccessful there would not be subsequent use of the lands for development and production of geothermal resources. Under such conditions, leases would terminate at the end of the 10-year primary term. However, in many instances such leases would be relinquished by the lessee at an earlier date to avoid additional lease payment costs. Exploration and lease provisions require that lands disturbed by unsuccessful exploration will have to be restored as nearly as possible to their original condition upon termination of these activities. Such restoration would include measures such as grading, installing proper drainage, soil stabilization, revegetation, removal of all equipment and supplies, proper removal or disposal of all wastes, filling in of holding ponds, etc. Except for scars from leveling of drilling sites, roads or other major earth movement, the areas should return to natural conditions in a short time. Changes in vegetative cover may result, depending upon whether native or non-native plants are used. In some instances, such changes could be beneficial for wildlife. In a few years, native vegetation may retake the area in some biomes. In the desert biome, aesthetic and vegetative impacts may last over a long period of years due to slow natural recovery factors.

Where exploration discloses the existence of economically attractive geothermal resources, the development and production of such resources for electric power generation, and possibly water and mineral by-products, could be expected to occur. Timing of such development would depend upon electric power markets, power transmission systems, and construction schedules. Once production begins, the geothermal resource would be withdrawn at a rate greater than the natural replenishment rate. Over a period of years (perhaps 20 to 50 years, depending upon the nature of the resource province) production capacity would be depleted to the point where further operation would not be economically feasible. When the reservoir is no longer capable of sustaining the geothermal operation, the leases would terminate, the facilities would be dismantled, and the land would be restored, insofar as practicable, to its original condition. Most of the area involved in the operation would have become well stabilized except for the actual areas used for the generation facilities, roads, or other structures or facilities. Removal of improvements would result in some disturbance, particularly in well and steam pipeline areas, but such disturbance would be of a temporary nature and subject to appropriate restoration. Unless the land areas occupied by production facilities were to be used for some subsequent and nonrelated purpose, they would be properly graded, drained, stabilized, and revegetated so that they would again become a part of the natural environment. Relatively large areas of level land would remain, such as the power generator site. Cuts and fills for roads, steam pipeline routes, likewise would remain visible. However, the combination of restoration and natural vegetative recovery would, over time, result in a near natural setting with only contour change as evidence of prior uses. The lands would return to their former productivity or they would be available for other appropriate uses.

C. Irreversible and Irretrievable Commitments of Resources (After USDI, Final Environmental Statement for the Geothermal Leasing Program, 1973)

The principal commitment of resources would be the depletion of thermal energy and water from the geothermal reservoir. Both of these resources are renewable but not within the life span of a specific project. Once they were depleted to the point where economic production could not continue, production would stop; facilities would be removed, and the area would be restored to as nearly a natural state as is practicable. The associated water produced by the operation could be of significant value if it were of sufficiently good quality, either naturally or by desalination, to be used for other purposes.

Compaction and resulting land subsidence that may result from the removal of geothermal fluids could have irreparable consequences. An equivalent amount of water storage would be lost. In developed areas, substantial adjustments might be required to compensate for such subsidence (agricultural lands, irrigation canals, and highway drainage). If seismic action should result from fluid withdrawal or reinjection, there could be considerable damage, depending upon the severity of such action.

Some on site or related ecological features such as plant life, wildlife, and aesthetics could be altered. Cuts and fills for plant sites, production wells, and roads could leave landscape scars. In some instances, roads might be retained as permanent access routes to facilitate other land uses. The extent of such alterations would depend upon the individual site and the nature of development.

Dedication of the land surface to industrial uses, generally, would result in land areas being used for wells, associated surface facilities, power plants, roads, and transmission lines. While not of a permanent nature, such uses would represent a commitment for a period of 25 to 50 years. This is a relatively long period in terms of human lifetimes and related alternative uses of these lands and their other resources. Human energy, money, and construction materials are other resources irretrievably committed in the development of geothermal steam. However, to the extent that these resources represent a commitment to increased power generating capacity to meet regional or national needs, their consumption would be necessary, regardless of the technology used in the generating process.

IV. ANALYSIS OF THE ALTERNATIVES

Alternative 1 - Withdraw from the proposed leasing areas acreage which has been identified in the Analysis of the Proposed Action as being a highly sensitive area.

This alternative prevents the leasing of areas that have been identified in the Analysis of the Proposed Action as sensitive areas, including, but not limited to: critical wildlife habitat, critical watersheds, areas containing threatened or endangered plants or animals, archaeological sites, outstanding natural areas, and buffer zones.

A. Environmental Impacts

The environmental impacts under this alternative would be the same as in the Proposed Action, except, that specific areas identified as highly environmentally sensitive are recommended for withdrawal from the proposed lease area.

1. Animals

Based on anticipated impacts discussed under Animals in the Analysis of the Proposed Action, leasing would not be allowed in San Lorenzo Canyon and Nogal Canyon South. There would be no surface disturbance within 1/2 mile (0.8 kilometer) of these two areas. The Jornada Lava Flow Area should not be leased because of its possible habitation by unique, threatened, or endangered species and its other outstanding natural qualities.

There should be no leasing within 1 mile (1.6 kilometers) of Sedillo and Socorro Springs on the Socorro Grant. The National Resource Land in T. 3 S., R. 1 W., Section 21: S½, should not be leased.

2. Other Resources

Based on the anticipated impacts discussed under Air, Soils, Geology, Water, Vegetation, Landscape Character, Land Uses, Cultural Resources, and Other Considerations, in the Analysis of the Proposed Action, no areas should be withdrawn from leasing in the proposed geothermal resource leasing area.

V. RECORD OF GOVERNMENTAL AGENCIES, GROUPS, AND PERSONS CONSULTED

Comments have been requested from the following:

Comments have been received from the names followed by an asterisk(*).

FEDERAL AGENCIES

- Department of Agriculture
  - Forest Service
  - Soil Conservation Service
- Department of the Interior
  - U.S. Fish and Wildlife Service*
  - Bureau of Reclamation
  - Bureau of Outdoor Recreation
  - U.S. Geological Survey*
  - U.S. Bureau of Land Management,
    - Albuquerque District Office
    - Las Cruces District Office*
    - Roswell District Office*
    - New Mexico State Office*

STATE AGENCIES

Environmental Improvement Agency
Middle Rio Grande Conservancy District
New Mexico Bureau of Mines and Mineral Resources*
New Mexico Game and Fish Department*
New Mexico State Oil Conservation Commission
New Mexico State Planning Office*

LOCAL AGENCIES

Alamo Chapter President
Belen Planning Commission
Central Rio Grande NRCD
East Valencia NRCD
Mayor of Magdalena
Middle Rio Grande Council of Governments
Salado NRCD
Salado Soil and Water Conservation District
City of Socorro
Socorro County Commissioners
Socorro NRCD
Southern Rio Grande Council of Governments
Torrance County Commissioners

ORGANIZATIONS

Audubon Society
Center for Environmental Resources
Central New Mexico Audubon Society
Concerned Sportsmen of New Mexico
Isaac Walton League of America
Natural Resources Defense Council
Nature Conservancy*
New Mexico Environmental Institute
New Mexico Gem and Mineral Society
New Mexico Geological Society, Inc.
New Mexico Mining Assn.
New Mexico Wilderness Study Commission
New Mexico Wildlife Society
Ranchers Exploration and Development
Sierra Club
Society for Range Management
Socorro Wildlife and Conservation Assn.
Soil Conservation Society of America
Students for Environmental Action

EDUCATIONAL INSTITUTES

Museum of New Mexico
New Mexico Institute of Mining and Technology
New Mexico State University

INDUSTRY

Amax Exploration Inc.
The Anaconda Co.
Bunker Hill Mining
Burmah Oil and Gas Co.
Calvert Geothermal Resources Inc.
The Cherokee and Pittsburgh Coal and Mining
Chevron Oil Co.
Cities Service
Colorado Plateau Geological Services, Inc.
Defensor-Chieftain
Deuterium Geothermal Corp.
Exxon Co.
Foote Mineral Co.
Geotronics Corp.
Gulf Oil Corp.
Hanna Mining Co.
Plains Electric Generation Coop
Kerr-McGee Corp.
New Mexico Oil and Gas Assn.
Northern Minerals

Phelps Dodge
Phillips Petroleum Co.
Public Service Co. of New Mexico
Shell Oil Co.
Socorro Electric Coop
Southern Union Products Co.
Teledyne Exploration Co.
Thermal Exploration Co.
Trans Ocean Oil Co.
Union Carbide Corp.
United Mineral Corp.
United Nuclear Corp.
XO Exploration

PERSONS

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C. L. Barrett
J. W. Covello
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E. E. Fogelson
Kathleen Griffith
Jack F. Grimm
Leland A. Hodges, Trustee
John M. Kelly
Sherman Nelson
Charles E. Serry
Emmet E. Wolter

VI. PUBLIC INTEREST

Copies of the draft of this document were made available for public review at the New Mexico Institute of Mining and Technology library, the Bureau of Land Management District Office in Socorro, and the public library in Socorro. Notices advertising the availability of the draft were sent to newspapers in the area. In addition, letters of notification were mailed to persons that expressed an interest in the area.

Copies of the draft were sent for review and comment to federal and state agencies, various conservation organizations and business and industry representatives that had expressed a direct interest in such material. Additional copies were given to people who made requests after the public announcements.

The mailing list for letters of notification, a list of the people who received copies of the draft, copies of news releases, letters of notification, and letters to recipients of the draft are available for public inspection at the BLM Socorro District Office.

A public meeting was held on Wednesday, October 20, 1976, to discuss the Proposed Socorro Peak Geothermal Resource Leasing EAR, in Socorro, New Mexico.

Few people submitted comments on the material presented at the public meetings or on the EAR and TR. Most of those who sent replies were representatives of state or federal government agencies or conservation groups.

Comments included notice of typographical and grammatical errors. Suggestions on how to improve the document as well as questions concerning accuracy of information were also received.

An effort has been made to incorporate the comments in appropriate sections. Correspondence and comments received concerning the Socorro Peak Geothermal EAR are on file in the BLM Socorro District Office, Socorro, New Mexico. This information is available for public inspection.

SIGNATURES

Solomon S. Katz

Solomon S. Katz, Geologist
Team Leader

5-19-77
Date

James L. Hancock

James L. Hancock
Environmental Coordinator

5-19-77
Date

Arlen P. Kennedy

Arlen P. Kennedy
District Manager

5-24-77
Date

GLOSSARY

Air pollution: the presence of contaminants in the air in concentrations that prevent the normal dispersive ability of the air and that interfere directly or indirectly with man's health, safety, comfort, or the full use and enjoyment of his property.

allotment: an area designated for the use of a prescribed number and kind of livestock under one plan of management.

allotment management plan (AMP): an allotment with an implemented grazing plan conducted in order to reach specific management objectives.

andesite: volcanic rock rich in the mineral plagioclase.

animal unit: considered to be one mature (1,000 pound) cow or the equivalent based upon average daily forage consumption of 26 pounds of matter per day.

animal unit month (AUM): the amount of feed or forage required by an animal-unit for one month.

annual vegetation: a plant that completes its life cycle and dies in one year or less.

arroyo: water carved gully or channel; dry wash, ravine.

aquatic animal: living wholly or chiefly in or on water and depending on water for their major life functions.

basalts: dark, fine-grained extrusive rock, generally volcanic.

benches: area of level or gently sloping land with steep slopes above and below formed by differential erosion of soils and rocks of varying resistance.

bosque: dense growth of trees and underbrush, generally, on the flood plain or adjacent to a stream or body of water.

breaks: irregular piece of ground. A deep valley, ravine or drainage. A line of ridges and associated spurs and small valleys at a mesa's edge or a river's head.

caldera: a large volcanic crater resulting from the collapse of a cylindrical block, usually 1 to 10 miles (1.6 to 16 km) in diameter.

capillary water (obsolete): the water held in the "capillary" or small pores of a soil, usually with soil water pressure greater than 60 centimeters of water.

cation: an ion that moves or would move toward a cathode, synonymous with positive ion.

cenozoic: the latest of the four eras into which geologic time is divided, about 65 million years ago to present.

coliform: a group of bacteria used as an indicator of sanitary quality in water. The total coliform group is an indicator of sanitary significance, because the organisms are normally present in large numbers in the intestinal tracts of humans and other warm-blooded animals.

cow yearlong (CYL): the amount of feed required to support one animal unit for one year.

custodial allotment: operator controlled allotment with little BLM input.

endangered species: those in danger of extinction throughout all or in a significant portion of their ranges.

erosion: detachment and movement of soil or rock fragments by water, wind, ice, or gravity.

escarpment: steep face or a ridge of high land; the escarpment of a mountain range is generally on that side nearest the sea.

evapotranspiration: evaporation water losses plus transpiration water losses.

exposure: direction of slope with respect to point of a compass.

fanglomerate: heterogenous materials in an alluvial fan that have been cemented into solid rock.

forage: all browse and herbaceous foods that are available to grazing animals.

forb: any herbaceous plant other than those in the grass, sedge, or rush families.

graben: a block, generally long compared to its width, that has been downthrown along faults relative to the rocks on each side.

heat flow units: unit of measurement of dissipation of heat from within the earth by conduction or radiation at the surface.

heavy metals: metals present in municipal and industrial wastes that pose long-term environmental hazards; they include boron, cadmium, cobalt, chromium, copper, mercury, nickel, lead, and zinc.

horst: a block of the earth's crust that has been uplifted along faults relative to the rocks on either side.

hydrologic cycle: the circuit of water movement from the atmosphere to the earth and return to the atmosphere through various stages or processes, as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration.

hydrophytes: floating plants found in aquatic environments.

intrusives: denoting igneous rocks in a molten state which have evaded other rock formations and cooled below the surface of the earth.

latite: type of extrusive volcanic rock, contains equal amounts of potash feldspars and plagioclase.

life zone: a classification of flora and fauna based on elevation and latitude.

lower sonoran: the life zone which extends from about 2,800 to 5,000 feet elevation. The major floral type is desert shrub.

magna: molten rock found within the earth.

montmorillonite: a group of clay minerals that are characterized by swelling in water.

m.y.: million years.

non-ionizing radiation: energy transmitted by short-wave action that does not cause a charge or ion build-up on the particles or material through which it passes.

oligocene: an epoch in the Cenozoic Era, about 36 million to 25 million years ago.

open space: land and water areas which are retained in essentially undeveloped state on a permanent or semi-permanent basis.

outstanding natural area, CFR 6225.0-5 (b): an area established to preserve scenic values and areas of natural wonder.

paleozoic: earliest epoch of the Cenozoic Era, about 65 million to 58 million years ago.

pennsylvanian: a geologic time period from about 310 million to 280 million years ago.

perlite: a volcanic glass having a high content of water. Upon rapid heating, perlite "pops" like popcorn producing a light-wright, stable, insulating material. Also used as a soil conditioner.

phytoplankton: the passively floating plant life of a body of water.

playa: the shallow central basin of a desert plain, in which water gathers after a rain and is evaporated.

pliocene: epoch within the Cenozoic Era, from about 13 million to 1 million years ago.

precambrian: that portion of geologic time before 600 million years ago.

primitive area: natural, wild, and undeveloped lands in settings essentially removed from the effects of civilization.

pyroclastic: a general term for material that has been explosively ejected from a volcanic vent.

range improvements: any structure or excavation to facilitate management of range or livestock.

raptor: birds that prey upon other animals.

revegetation: the re-establishment or improvement of vegetation through management practices or chemical or mechanical means.

riparian: of, pertaining to, situated or dwelling on the bank of a river or other body of water.

rhyolite: fine grain equivalent of a granite.

rift: a large strike-slip fault parallel to the regional structure.

rookery: a breeding place or colony of other gregarious birds or animals.

series: the soil series is a group of soils having horizons similar in differentiating characteristics and arrangement in the soil profile, except for texture of the surface portion, or if genetic horizons are thin or absent, a group of soils that, within defined depth limits, is uniform in all soil characteristics diagnostic for series.

shrub: a plant that has persistent, woody stems and a relatively low growth habit, and that, generally, produces several basal shoots instead of a single bole.

silicic: containing an abundance of silica or silicon.

soil association: 1. a group of defined and named taxonomic soil units occurring together in an individual and characteristic pattern over a geographic region, comparable to plant associations in many ways, Sometimes called "natural land type." 2. a mapping unit used on reconnaissance or generalized soil maps in which two or more defined taxonomic units occurring together in a characteristic pattern are combined because the scale of the map or the purpose for which it is being made does not require delineation of the individual soils.

soil structure: the combination or arrangement of primary soil particles into secondary particles, units, or peds. The secondary units are characterized and classified on the basis of size, shape, and degree of distinctness into classes, types, and grades, respectively.

soil survey: a general term for the systematic examination of soils in the field and in laboratories; their description and classification; the mapping of kinds of soil; the interpretation of soils according to their adaptability for various crops, grasses, and trees; their behavior under use or treatment for plant production or for other purposes; and their productivity under different management systems.

subsoil: the B horizons of soils with distinct profiles. In soils with weak profile development, the subsoil can be defined as the soil below the plowed soil (or its equivalent of surface soil), in which roots normally grow. Although a common term, it cannot be defined accurately. It has been carried over from early days when "soil" was conceived only as the plowed soil and that under it as the "subsoil."

surface disturbance: the result of any activity changing the existing surface including off-the-road vehicle use.

surface occupancy: permanent or semi-permanent structures, including drill rigs, placed on National Resource Land.

thixotropic: the property of becoming fluid when shaken -- the change is reversible.

threatened species: those which are likely to become endangered within the foreseeable future throughout all or a significant portion of their ranges.

topsoil: 1. earthy material used as top-dressing for house lots, grounds for large buildings, gardens, road cuts, or similar areas. It has favorable characteristics for production of desired kinds of vegetation or can be made favorable. 2. the surface plow layer of a soil; also called surface soil. 3. the original or present dark-colored upper soil that ranges from a mere fraction of an inch to two or three feet thick on different kinds of soil.

4. the original or present A horizon, varying widely among different kinds of soil. Applied to soils in the field, the term has no precise meaning unless defined as to depth or productivity in relation to a specific kind of soil.

transition zone: the life zone which extends from about 7,000 to 9,500 feet elevation. The major floral type is ponderosa pine.

transpiration: the giving off of moisture through the surface of leaves and other parts of plants.

tuff: a rock formed of compacted volcanic fragments, generally smaller than 4 mm in diameter.

upper sonoran: the life zone which extends from about 4,500 to 8,000 feet elevation. The major floral type is pinyon-juniper.

vascular plants: plants with specialized conductive tissues in organs distinguished as roots, stems, and leaves, as opposed to lower plants without such organs.

vegetative aspect: the visual first impression of vegetation at a particular time or as seen from a specific point.

vegetative type: a plant community with distinguishable characteristics.

visual resource: the land, water, vegetative, animal, and other features that are visible on all National Resource Lands.

visual sensitivity level: an index of the relative importance or value of visual response to an area in relation to other areas in the planning unit.

visual zones: the area that can be seen as foreground, middleground, background, or seldom seen.

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APPENDIX C

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Area Geothermal Supervisor's Office
Conservation Division, MS 92
345 Middlefield Road
Menlo Park, CA 94025

JAN 26 1976

Memorandum

To: District Manager, Bureau of Land Management, Socorro
New Mexico 87801

From: Acting Area Geothermal Supervisor

Subject: Hydrological Input to the Strawberry Peak EAR

Enclosed for your use is our hydrological input to the subject EAR you are preparing. If you have any questions concerning the input, please contact Kenneth Rock of my staff at FTS 467-2848.

The most recent attempt to resolve international boundary differences involving the Rio Grande was climaxed by a treaty between the United States and Mexico, signed on November 23, 1970. Copies of the treaty and related documents are for sale by the Superintendent of Documents, Treaties and Other International Acts Series, 7313, U.S. Government Printing Office.

Bruce H Hellier

BUREAU OF LAND MANAGEMENT
SOCORRO, NEW MEXICO

JAN 31 1977

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Hydrological Input to the Strawberry Peak, New Mexico Environmental Analysis Record

By

Kenneth N. Rock
Office of the Area Geothermal Supervisor
U. S. Geological Survey
Menlo Park, California

INTRODUCTION

The Strawberry Peak Geothermal Leasing Area is located in the central part of the Rio Grande drainage basin of New Mexico. Approximate boundaries of the study area are shown in Fugure 1. The Rio Grande, the most important river in New Mexico, heads in the San Juan Mountains of Colorado. It flows generally south-southwest across New Mexico and drains large portions of several states before emptying into the Gulf of Mexico. Total drainage at the outlet is 83,400 square kilometers (32,207 square miles). The study area includes less than four percent of this total. The total drainage area of the Rio Grande at San Acacia, just north of the study area, is 69,300 square kilometers (26,700 square miles) with an average runoff of about 102,300 hectare-meters, or about 829,000 acre-feet per year (Surface Water Supply of the U.S., 1946).

CLIMATE

Climate is generally semi-arid with precipitation averaging about 25 centimeters per year (10 inches per year), 40 percent of which occurs during the summer months as scattered, high-intensity thunderstorms. There is only occasional rain or snow during the mild and dry winters. Relative humidity is low most of the time. The amount of snow that falls increases considerably with elevation, as does total annual precipitation. The seasonal differences in precipitation are due to differences in the overall movement of air masses at different seasons, whereas, the regional differences within the county, even at equal altitudes, are due to the influence of topographic barriers on the movements of air masses. Table 1 presents selected information about average annual, maximum and minimum temperatures at several weather stations in or near the study area. At Socorro, there was an average of 196 frost-free days per year for a forty year period.

SURFACE WATER

The only true perennial flow in the area is the Rio Grande. All arroyos to the east, as well as those coming from the Lemitar and Socorro mountains and the Chupadera Hills to the west, drain directly into the Rio Grande, but none of these streams have perennial flow. The east side of the Magdalenas drains

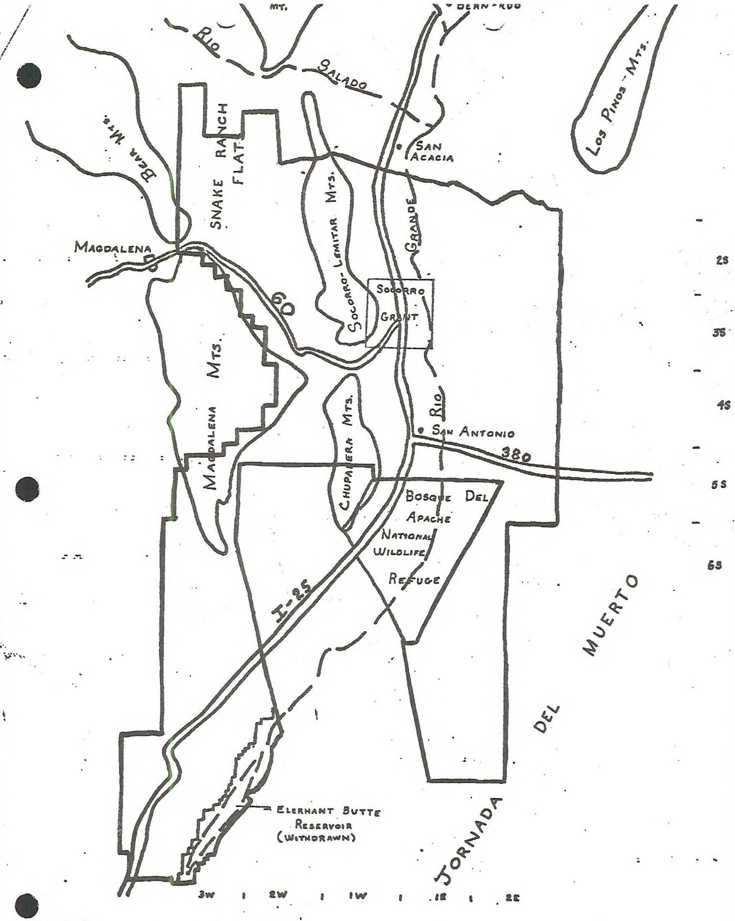


Figure 1.
PROPOSED STRAWBERRY PEAK GEOTHERMAL LEASING AREA

N.M.P.M.

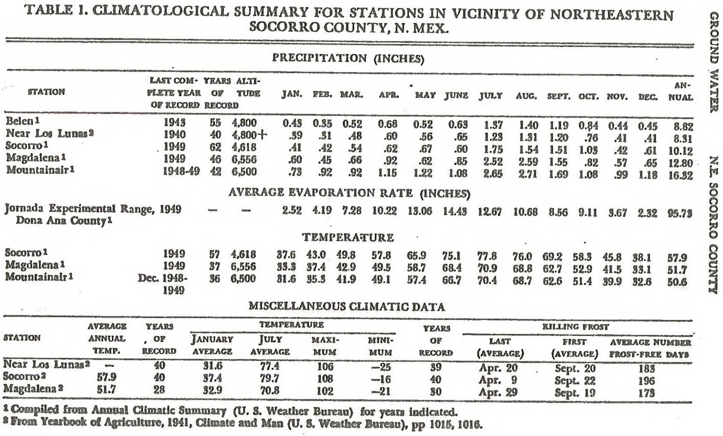


TABLE 1. CLIMATOLOGICAL SUMMARY FOR STATIONS IN VICINITY OF NORTHEASTERN SOCORRO COUNTY, N. MEX.

STATION	LAST COMPLETE YEAR OF RECORD	YEARS OF RECORD	ALTITUDE	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL
PRECIPITATION (INCHES)																
Belen[1]	1943	55	4,800	0.43	0.35	0.52	0.68	0.52	0.63	1.37	1.40	1.19	0.84	0.44	0.45	8.82
Near Los Lunas[2]	1940	40	4,800+	.39	.31	.48	.60	.56	.65	1.23	1.31	1.20	.76	.41	.41	8.31
Socorro[1]	1949	62	4,618	.41	.42	.54	.62	.67	.60	1.75	1.54	1.51	1.03	.42	.61	10.12
Magdalena[1]	1949	46	6,556	.60	.45	.66	.92	.62	.85	2.52	2.59	1.55	.82	.57	.65	12.80
Mountainair[1]	1948-49	42	6,500	.73	.92	.92	1.15	1.22	1.08	2.65	2.71	1.69	1.08	.99	1.18	16.32
AVERAGE EVAPORATION RATE (INCHES)																
Jornada Experimental Range, Dona Ana County[1]	1949	—	—	2.52	4.19	7.28	10.22	13.06	14.43	12.67	10.68	8.56	9.11	3.67	2.32	95.73
TEMPERATURE																
Socorro[1]	1949	57	4,618	37.6	43.0	49.8	57.8	65.9	75.1	77.8	76.0	69.2	58.3	45.8	38.1	57.9
Magdalena[1]	1949	37	6,556	33.3	37.4	42.9	49.5	58.7	68.4	70.9	68.8	62.7	52.9	41.5	33.1	51.7
Mountainair[1]	Dec. 1948-1949	36	6,500	31.6	35.3	41.9	49.1	57.4	66.7	70.4	68.7	62.6	51.4	39.9	32.6	50.6

MISCELLANEOUS CLIMATIC DATA

STATION	AVERAGE ANNUAL TEMP.	YEARS OF RECORD	TEMPERATURE				YEARS OF RECORD	KILLING FROST		
			JANUARY AVERAGE	JULY AVERAGE	MAXIMUM	MINIMUM		LAST (AVERAGE)	FIRST (AVERAGE)	AVERAGE NUMBER FROST-FREE DAYS
Near Los Lunas[2]	—	40	31.6	77.4	106	−25	39	Apr. 20	Sept. 20	183
Socorro[2]	57.9	40	37.4	79.7	108	−16	40	Apr. 9	Sept. 22	196
Magdalena[2]	51.7	28	32.9	70.8	102	−21	30	Apr. 29	Sept. 19	173

[1] Compiled from Annual Climatic Summary (U. S. Weather Bureau) for years indicated.

[2] From Yearbook of Agriculture, 1941, Climate and Man (U. S. Weather Bureau), pp 1015, 1016.

TABLE 1 - Climatological data.

Source: Spiegel, Zane, Geol. and Ground Water Resources of N. E. Socorro County, New Mexico, 1955 into the Snake Ranch Flats, shown in Figure 1. The southern part of the flats eventually drains through arroyos such as Nogal, north of Socorro Mountain. The northern portion of the Snake Ranch Flats drains to the Rio Salado, a major tributary of the Rio Grande (just north of the study area) via La Jencia Creek.

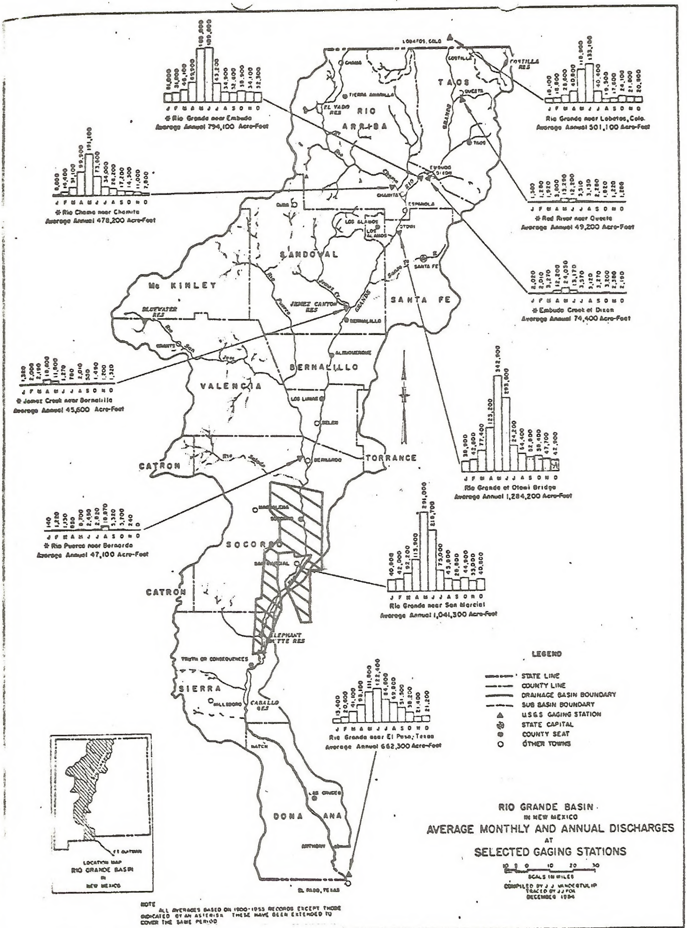
Average monthly and annual discharges at selected gaging stations along the Rio Grande are presented in Figure 2. It is intended, primarily, to graphically illustrate comparative annual discharge at various points within the drainage basin and show a long-term pattern of the monthly discharge. Selected average runoff and peak discharge information is presented in Table 2. For convenience, average runoff is given in terms of inches per year. Comparing these figures to annual precipitation, the data suggest that most of the precipitation is lost to evapotranspiration or used as groundwater recharge since less than 10 percent occurs as runoff. Figure 3 shows most of the springs in the Socorro region, which includes most of the northern part of the study area (outlined with heavy lines).

To reduce wasteful and non-beneficial uses of the total water supply, substantial channel-rectification works were begun in 1950. These have significantly reduced the waste lost to non-beneficial uses.

Base flow and runoff in the Rio Grande basin are regulated by several methods. Large reservoirs are the most useful means of regulation. There are six reservoirs in the Rio Grande basin which have a capacity of more than 3,700 hectare-meters (30,000 acre-feet). The largest, Elephant Butte Reservoir, located in the southern portion of the study area, has a current usable capacity of 270,700 hectare-meters (2,195,000 acre-feet) of water. It is used for flood control, irrigation, sediment retention, power production, and recreation.

Some areas in the basin have been subject to spectacular flooding in the past. Probably the most notable flood was at San Marcial in 1929, just south of the central part of the study area. Most of the town was destroyed, and many parts of the San Acacia-Socorro area were inundated. Other memorable floods have occurred in the lowlands near the Rio Grande, but the methods of runoff and streamflow regulation have essentially eliminated the possibility of flooding in areas where large amounts of personal property could be damaged.

Besides reservoirs, other regulating facilities in the Rio Grande basin include rectified channels, dikes to control channel position, canals for water distribution, and drains to alleviate flooding or swamping in low areas of flood plains.



igure 2 - Monthly and Annual Discharge

rce: State Planning Office, 1967

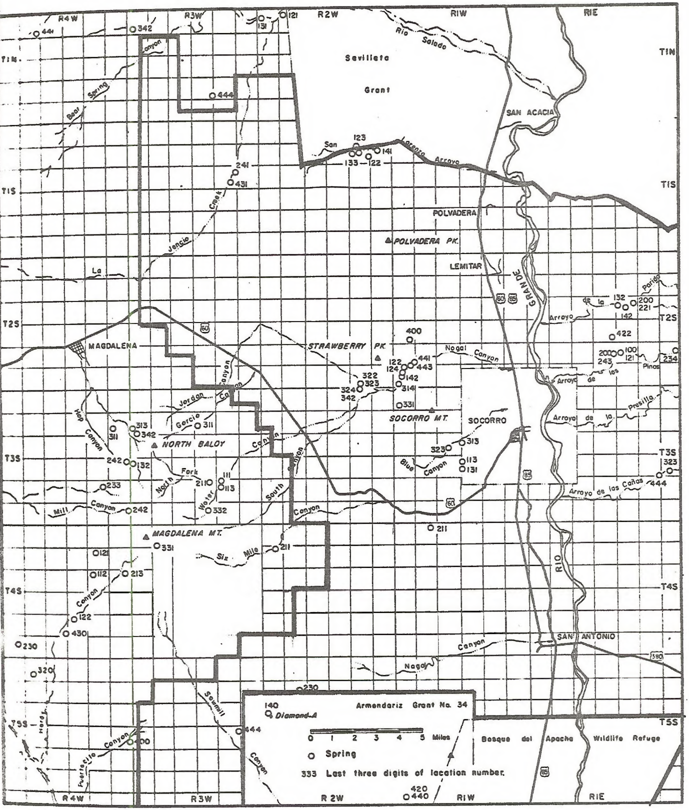


Figure 3 -· Spring locations in the Socorro region, New Mexico.

Source: Hall, F.R., Springs in the Vicinity of Socorro, New Mexico; Guidebook of the Socorro Region, Fourteenth Field Conference, 1963.

GROUND-WATER

Two principal aquifer systems or groups supply water to wells in the area. They are the valley fill and bedrock. Valley fill includes sediments that have been deposited along tributary streams and have filled the Rio Grande trough. The upper portion of the valley fill deposit is quaternary alluvium consisting of unconsolidated gravels, sands, and silts which vary in thickness from one or two meters on the upper valley slopes and along arroyo bottoms to perhaps thirty meters and more in the river flood plain (Waldron, 1956). Underlying this alluvium and cropping out on the surface in several places, is the Sante Fe Formation of Quaternary-Tertiary age. Total thickness of the valley fill is as much as 2,745 meters (9,000 feet), which makes it the most reliable aquifer for large quantities of water in the basin (Bjorklund, 1961).

Bedrock aquifers in the Rio Grande basin may be composed of sandstone, conglomerate, or limestone. Generally, beds of shale, mudstone, siltstone, or clay yield little or no water directly to wells. Extrusive volcanic rocks may yield large amounts of ground-water, especially where fractures may be tapped. Most lava flows in the basin, however, are not reliable aquifers. For the most part, bedrock aquifers are used only at places far enough away from the principal drainage system, where there is no saturated valley fill. They generally yield only small to moderate amounts of water to wells; however, some bedrock aquifers, principally limestone, may yield large amounts of water to wells locally.

Water table contours in Figure 4 indicate that the major movement of ground water is parallel to the Rio Grande. In Socorro Valley, which includes only the central part of the study area (shown in white in Figure 4), both the land suface and the water table slope to the south at a gradient of .85 meters per kilometer (4.5 feet per mile). Although the land surface becomes steeper towards the mountains on either side, the water table rises very little, normal to the Rio Grande, as indicated by the nearly horizontal water level contours. The water table is generally less than 2.5 meters (8 feet) from the ground surface near the Rio Grande, but towards the mountains, it may be as much as 150 meters (500 feet) below the land surface.

The subsurface flow of ground water can be calculated using the following information:

(1) slope of water table of .85 meters per kilometer (or 100 feet in 22.6 miles)

(2) effective aquifer width of 9.7 kilometers (6 miles)

(3) transmissibility coefficient of 4.1 million liters per day per meter (about 330,000 gallons per day per foot)(average of coefficients from tests in the Lemitar and Socorro areas (Hantush, 1961)).

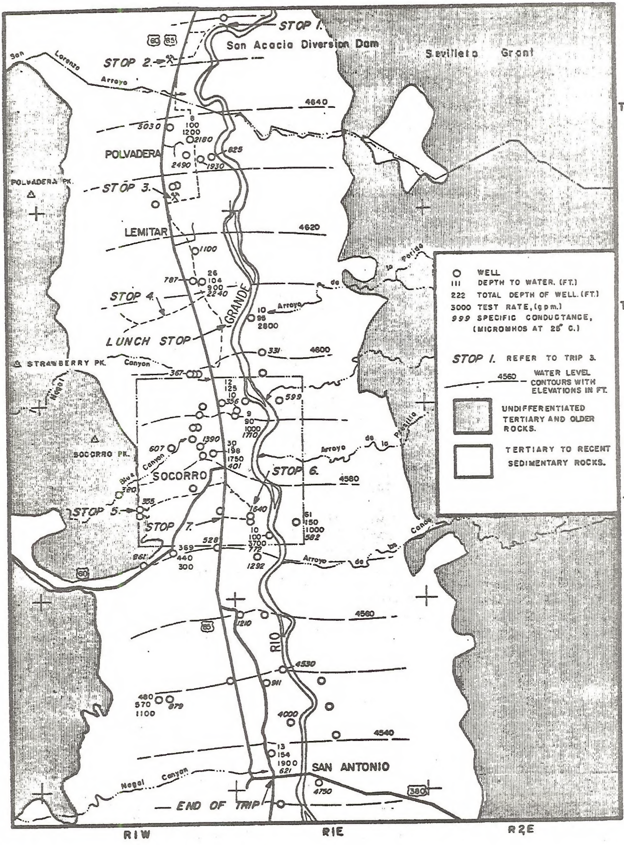


Figure 4 - Selected well data on water table contours, Socorro Valley.

Source: Bushman, F.X., Groundwater in the Socorro Valley, Guidebook of the Socorro Region, Fourteenth Field Conference, 1963.

Thus, subsurface ground-water flow in Socorro Valley is about 3.33 hectare-meters per day (27 acre-feet per day).

Using similar data and assumptions, Hantush (1961) calculated that more than 481,000 hectare-meters (3.9 million acre-feet) of water is in storage in the upper half of the aquifer, assuming a thickness of at least 180 meters (600 feet). Combined with pumping, storage space would become available to permit more effective regulation of the surface flows.

WATER QUALITY

Clark and Summers (1971) have made extensive chemical analyses of wells and springs in the Socorro and Magdalena areas in Socorro County. Their results, plus data from other sources, indicate that springs east of the Rio Grande are, for the most part, characterized by high sulfate content and relatively high total dissolved solids. Also characteristic of these springs is their low chloride content. The consistent analyses probably reflect the chemical nature of the water-bearing rocks. Temperatures are close to the mean annual air temperature.

Springs west of the Rio Grande are low in chloride and generally low in sulfate, but show a much greater diversity than do those of the east. Although flow rates are not available, most usually have low yields.

WATER USE

Water is used primarily for irrigation and domestic uses, with smaller quantities used for livestock. The mining industry is also a potential user of large amounts of water, but current information about water needs of mining activities in the study area is not available.

Between San Acacia and Bosque del Apache National Wildlife Refuge (south of San Antonio on Figure 1), there are about 13,000 acres of irrigated lands. These lands are located almost exclusively along a narrow band bordering the Rio Grande, as illustrated in Figure 5. Surface water diverted at San Acacia is the principal source of irrigation water, with well water assuming a more important role during summers of inadequate supply. There are about 65 irrigation wells in the middle valley of the Rio Grande between San Acacia and San Antonio. They range in capacity from less than 1,100 liters per minute (300 gallons per minute) to 9,500 liters per minute (2,500 gallons per minute) and are anywhere from 9 to 60 meters (30 to 200 feet) deep.

THERMAL SPRINGS

Sections 9, 16, and 22 of T. 3 S., R. 1 W. contain one of the largest thermal anomalies in New Mexico. Hot water issues from three galleries which were built to intercept the flow of natural springs. This anomaly, known as the Socorro Thermal Area, is centrally located in the study area about three miles west of Socorro. Temperatures of water from the galleries have been remarkably consistent and with few exceptions, all measurements fall within the range of 32.7 to 33.1°C (90.9 to 91.6°F).

Chemical analyses of water samples taken in the Socorro Gallery indicate that sodium is the predominant dissolved cation, ranging in concentration from 50 to 68 parts per million (for 20 samples). It is interesting to compare this information with the data obtained from samples collected in the Magdalena Mountains to the west, where calcium is the predominant dissolved cation, ranging in concentration from about 70 to 90 parts per million. Apparently, cation exchange or introduction of sodium ions takes place as the water flows to the east and passes through altered rhyolitic breccias (Hall, 1963). The sodium is probably derived from albite (sodium plagioclase) in the rhyolite. Thus, the chemical nature of the thermal water is primarily determined by the material over or through which it passes.

Dissolved-solids content of surface water in the Rio Grande is strongly dependent on the tributary from which most of the flow is derived at a given time. For example, the dissolved solids content of water in the Rio Puerco (north of the study area) is generally very high compared to that of the Rio Grande north of their confluence. Therefore, during runoff in the Rio Puerco, the dissolved-solids content in the Rio Grande at San Acacia is usually higher than when the Rio Puerco is not flowing.

Sulfate is the main chemical constituent in surface waters of the Rio Grande because it is readily soluble in the form in which it occurs and is pervasive throughout the study area. Table 3 presents a summary of dissolved solids information for selected chemical quality stations in or near the study area. It is important to exercise caution in interpreting the data which imply that dissolved solids decrease from San Acacia to below Elephant Butte Dam. First, the data are maximum and minimum figures. Thus, the high reading of 2,950 parts per million at San Acacia probably occurred when the Rio Puerco was contributing an unusually high proportion of runoff to the Rio Grande, as mentioned earlier. Also, the relatively higher quality water in the reservoir tends to dilute the inflowing, lower quality water, which could give unrealistic water quality data. Finally, the fact that irrigation waste water is returned to the Rio Grande (directly or indirectly) cannot be overlooked. The wastes could, of course, add significant amounts of dissolved solids and water quality data would be strongly affected by where and when the sample was taken.

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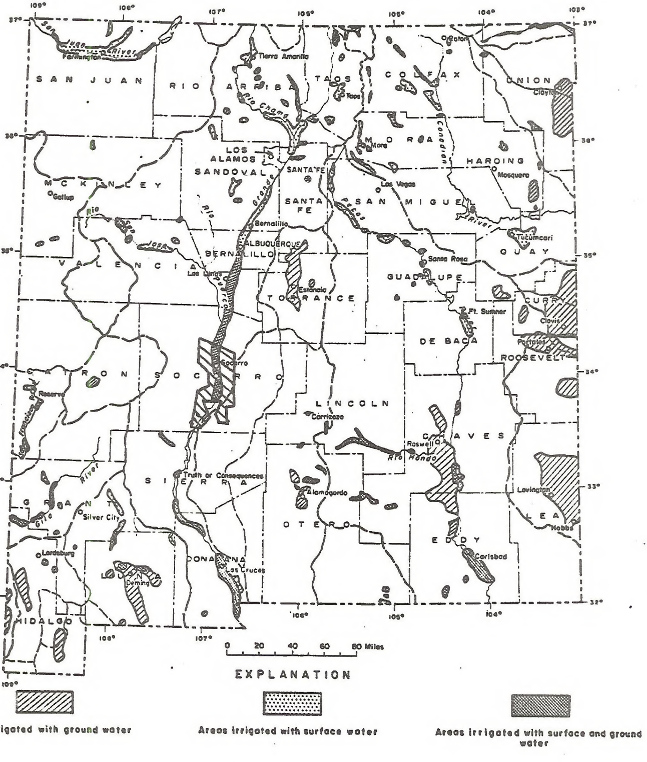

Figure 5 - Irrigated areas in New Mexico, 1965

Source: State Planning Office, 1967.

Station	Drainage Area (Sq Mi)	Average Runoff		Peak Discharge		
		acre-ft/yr	inches/yr	yrs of record	cfs	cfs/sq mi
Rio Grande at San Acacia	26,770	828,900	.58	22	≥50,000	1.87
Rio Grande at San Antonio	27,400	391,700	.27	5	50,000	1.82
Rio Grande at San Marcial	27,700	970,800	.66	65	50,000	1.81
Rio Grande below Elephant Butte Dam	29,450	771,000	.49	45	8,220	.28
Rio Puerco near Bernardo	6,220	40,900	.12	20	35,000	5.63
Rio Salado near San Acacia	1,380	9,050	.12	13	27,400	19.9

TABLE 2 - Selected Steamflow and Reservoir - Contents Gaging Stations Adapted from N. M. State Engineer's Office, 1967, Water Resources of New Mexico: Occurrence, Development and Use.

Station	Years of Record	Daily Dissolved Solids Concentration (PPM)		Dissolved Solids Load (Tons/Day)	
		MAX	MIN	MAX	MIN
Rio Grande near Bernardo	4	1,080	207	8,270	3.86
Rio Grande at San Acacia	18	2,950	183	16,100	.2
Rio Grande Conveyance Channel at San Marcial	6	2,010	390	4,430	.58
Rio Grande Floodway at San Marcial	27	1,950	233	16,400	.72
Rio Grande below Elephant Butte Dam	6	1,170	426	3,790	5.2

TABLE 3 - Summary of Selected Chemical Quality Station Records for Streams
Adapted from N.M. State Engineer Office, 1967, Water Resources of New Mexico: Occurrence, Development and Use

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Area Geothermal Supervisor's Office
Conservation Division, MS 92
345 Middlefield Road
Menlo Park, CA 94025

FEB 25 1977

Memorandum

To: District Manager, Bureau of Land Management, Socorro, New Mexico

From: Area Geothermal Supervisor

Subject: Input to the Strawberry Peak EAR

Attached, as requested, is the additional input to the subject EAR concerning the impacts of geothermal development on water resources (Attachment A). We have cited mitigating measures corresponding to most impacts and have identified as Unavoidable Impacts those which cannot be mitigated. Attachment B discusses cooling water requirements for various types of geothermal plants.

We do not feel it is our position, however, to formulate stipulations to protect water resources in excess of the protection already afforded by the mitigating measures identified in Attachment A. Given the enclosed information and the hydrologic input already provided, however, your office may feel that additional Special Lease Stipulations are required to further protect the water resources of the Strawberry Peak area.

We hope the delay in providing this information has not created any serious difficulties.

Reid T Stone

Enclosure

BUREAU OF LAND MANAGEMENT
SOCORRO, NEW MEXICO

FEB 28 1977

[illegible] Sol.

ATTACHMENT A

POTENTIAL IMPACTS OF GEOTHERMAL DEVELOPMENT ON WATER RESOURCES AND CORRESPONDING MITIGATING MEASURES

Listed below are the activities occurring at each phase of geothermal development which can have adverse effects on water resources. Appropriate mitigating measures follow the descriptions of the potential impacts.

I. EXPLORATION PHASE

A. Deep Exploration Wells: drilled with conventional drilling rig to depths of several thousand feet.

1. Potential Impacts.

    a. Possible stream sedimentation as a result of drill site and access road construction. The likelihood and severity depend on the slope of the terrain, proximity to surface water, amount of rainfall, erodibility of the soil, design of the pad and roads, and success of revegetation efforts.

    b. Drilling of each well requires approximately 60,000 gal. of water.

    c. Possible seepage of fluids through sump, contaminating shallow ground water.

    d. Possible interzonal communication of ground water leading to contamination of fresh-water zones.

    e. Possible spillage or escape, as in a blowout, of toxic materials, eventually reaching surface water.

2. Mitigating Measures.

    a. Plans of Operation, as per 30 CFR 270.34(h), must present methods to prevent erosion and subsequent sedimentation in streams, subject to the approval of the Supervisor and land management agency. GRO Order #4, General Environmental Protection Requirements, Section 5 also requires lessees to "provide adequate erosion and drainage control to prevent sediments from disturbed sites from entering water courses." Plans of Operation should, as criteria for approval, describe extent and ratios of cut-and-fill slopes, compaction methods, a site drainage plan, and revegetation procedures. The latter is required by GRO Order #4, Section 2. Buffer zones may be established such that there may be no surface occupancy within a specified distance from a water course.

b. Plans of Operation, as per 30 CFR 270.34(c), must state the source of water.

c. Proposed sump linings must receive approval from the Supervisor before drilling may proceed. Lining requirements vary from area to area depending on the self-sealing properties of native soils.

d. The well-casing requirements imposed by GRO Order #2, Drilling, Completion and Spacing of Geothermal Wells, effectively eliminates the possibility of interzonal communication of ground water.

e. To insure containment of toxic compounds, Plans of Operation should specify that drainage from the drill pad will be directed into the sump. After drilling is completed, sump fluids must be disposed of in a manner approved by the Supervisor (see 30 CFR 270.34(g) and GRO Order #4, Section 9). Blowout preventers must be installed and tested, as per GRO Order #2, Section 2.

B. Well Testing: in a hot water geothermal system, wells must be flow tested for a period usually lasting one or two days. Similarly, dry steam wells must be vented not only to test the producibility of the well but to clean out the bore hole as well.

1. Potential Impacts:

a. In a hot water system, if the geothermal water is of lower quality than local ground or surface water, there is a possibility of contamination of these water supplies. If the geothermal water is of comparable or higher quality than local ground or surface water, there may be beneficial effects from the increased water supply.

b. Uncontrolled venting of a dry steam well can spread pulverized bore hole material (as suspended particulate matter) over the drill pad and vicinity, possibly leading to stream sedimentation.

2. Mitigating Measures;

a. Test fluids may be either reinjected into the geothermal reservoir (the preferred method) or stored in holding ponds, usually constructed by expanding the storage capacity of the sump. Injection wells must meet the criteria established by GRO Order #4, Section 9C. If fluids are stored in a holding pond and allowed to evaporate, the pond must have an impermeable liner.

b. Return-line discharge should be water washed to remove cuttings. This is a standard condition for approval of a Plan of Operation for drilling in a known dry steam field.

II DEVELOPMENT PHASE

A. This phase is characterized by more intensive deep well drilling as a known resource is developed to a level capable of power production. Successful wells are capped and left on a stand-by status, awaiting sufficient development (usually 12-20 wells) to warrant construction of a power plant. The potential impacts on water resources and corresponding mitigating measures are the same as but incremental to those described under I.A. and I.B. above.

III PRODUCTION PHASE

A. Power Plant Construction.

1. Potential Impacts: earth moving activities similar to drill pad and access road construction may lead to erosion and stream sedimentation.

2. Mitigating Measures: the measures identified under I.A. 2.a. are applicable in this case as well.

B. Power Generation (lasting up to 30 years or more).

1. Potential Impacts.

a. Large quantities of waste fluid and steam condensate must be disposed of. As in I.B.1.b. above, high quality water may be used for agricultural, domestic or space heating purposes, with corresponding benefits. Low quality fluids present the risk of spillage or ground-water contamination.

b. Cooling water is necessary to condense the flashed steam after it passes through the turbine. This could impact local water supplies if cooling water must be obtained from outside sources. See Attachment B.

c. Continuous withdrawal of fluids from a sedimentary basin could result in subsidence if the fluids are not reinjected. This could be a serious problem if there is irrigated farm land nearby, since the surface slope gradient may be altered.

d. Net water loss from the geothermal system, by evaporation from standard "wet" cooling towers, of 3,500 to 4,000 acre-feet per year per 100 MW generating capacity (assuming a vapor pressure of 100 psi at the steam turbine). This loss could affect local water supply if there was hydraulic connection between the geothermal reservoir and shallow ground-water aquifers. The degree of hydraulic connection, if any, depends on the nature of the system. No such effects have been observed to date.

2. Mitigating Measures.

a. Injection back into the geothermal reservoir is the best method of fluid disposal and is required for low-quality fluids by GRO Order #4, Section 9A.

b. Cooling water may be obtained by recycling the condensed steam or cooled fluids, eliminating the demand for cooling water from outside sources. This measure should be included in Plans of Production or otherwise may be required as a condition for approval of such Plans. If highly corrosive fluids are produced or a binary heat exchanger type plant is employed, however, cooling water may be required from outside sources. A binary system is a worst-case example, requiring about 6,000 acre-feet per year per 100 MW of power production.

c. Reinjection of produced fluids may be required under GRO Order #4, Section 8, regardless of quality, if subsidence is found or expected to occur. Section 8 of GRO Order #4 requires lessees to survey the land surface prior to and during production in order to detect subsidence.

d. In critical water shortage areas, dry cooling towers may be used. These lower the efficiency of the plant, however, and may raise capital costs such that the project becomes economically infeasible.

C. Replacement Wells.

Additional wells must be drilled periodically over the life of the reservoir to maintain pressure suitable for power production. The potential impacts and mitigating measures are the same as those described under I.A. and I.B.

IV CLOSE OUT

A. This phase is characterized by termination of operations and dismantling of equipment.

1. Potential Impact: Erosion and subsequent sedimentation may result as bare soil is exposed again.

2. Mitigating Measure: Revegetating exposed soil may be required.

UNAVOIDABLE IMPACTS

The only unavoidable impact on water resources is the evaporative loss from the system described in III B.1.d. above, which may or may not affect local ground water supply. Use of dry cooling towers would significantly reduce evaporative losses, but could render the project economically infeasible. If cooling water is required from outside sources, as described in III B.2.b. above there could be an impact on local water resources.

ATTACHMENT B

IMPACT OF GEOTHERMAL DEVELOPMENT ON WATER RESOURCES

Water demand for geothermal operations varies with the size of the field and the type of power plant used. The water requirement for different phases of geothermal operations is summarized in Table 1. On the basis of our current understanding of geothermal development, an average geothermal field could consist of two to three power plants producing approximately 110 to 160 MW per year. Therefore, assuming the use of an isobutane plant, a conservative estimate of water would range from approximately 6,200 acre-feet per year to 9,300 acre-feet per year of make-up water for an average field. Fig. 1 is a schematic of the isobutane cycle. Estimated minimum make-up water demand, assuming one isobutane power plant, would be approximately 3,100 acre-feet per year; estimated maximum make-up water demand, based on the development of a 700 MW generating capacity using isobutane power plants, would be approximately 41,000 acre-feet per year.

It is important to note that these cooling water requirements need not necessarily come from local surface reservoirs or water wells, but may be obtained wholly from produced geothermal waters. The final choice to use either local or produced water would depend on availability of local water and comparison of quality, characteristics and the economics of each source.

Blow-down water produced by the cooling cycle, approximately 97 acre-feet per year per plant, is injected. The difference between the make-up water and the blow-down fluid, approximately 3,000 acre-feet per year per plant, is lost through evaporation. The high concentration of dissolved solids in the returned fluid precludes re-cycling and its use as make-up water.

TABLE 1 - ESTIMATED WATER DEMAND FOR GEOTHERMAL OPERATIONS

OPERATION	WATER DEMAND /1
Exploration /2	0.18 acre-ft/well
Development /2	3.7 acre-ft/20 wells
Power Plant Operation	
Isobutane Power Plant	- 3,100 acre-ft/yr
Direct Steam Power Plant	+ 430 acre-ft/yr
Flashed Steam Power Plant	- 200 acre-ft/yr

/1 + Water in excess in Geothermal Operations

- Water required from either produced water or outside source.

/2 Assuming 20 producing wells required per power plant.

/3 Water demand on basis of a 55 MW generator and a well-head temperature of 405°F.

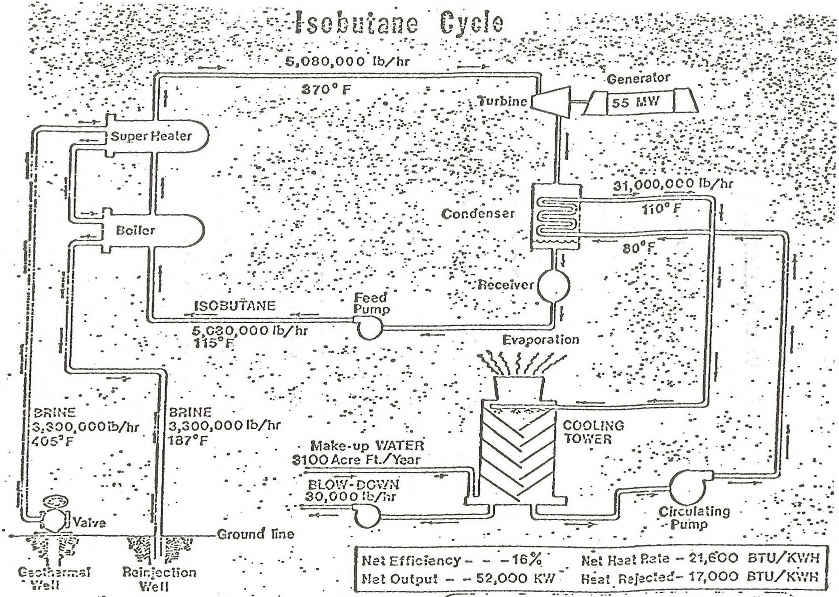

Fig. 1 -- Plant Cycle Used in Computing Geothermal Water Demand

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Division of Ecological Services
Suite C
3530 Pan American Highway, N.E.
Albuquerque, New Mexico 87107

IN REPLY REFER TO:

BUREAU OF LAND MANAGEMENT
SOCORRO, NEW MEXICO

FEB 25 1977

DIV. AREA
DIST. MGR.
ADMIN
RESOURCES
OPERATIONS
SARA
JRA

February 18, 1977

Memorandum

To: District Manager, Bureau of Land Management
Socorro, New Mexico

From: Field Supervisor, Ecological Services
Albuquerque, New Mexico

Subject: Socorro Peak Geothermal EAR

By letter dated December 17, 1976 you requested our input into the subject EAR. Specifically, the fish and wildlife resources and related habitat, the impacts geothermal development will produce, and recommended stipulations and mitigation measures.

A variety of wildlife exists within the proposed lease area. Game species include the mule deer (Odocoileus hemionus); pronghorn (Antilocapra americana); two species of quail, the scaled or blue quail (Callipepla squamata) and the Gambel's quail (Lophortyx gambelii); and the mourning dove (Zenaidura macroura). Non-game species occuring in the area include bobcat (Lynx rufus), coyote (Canis latrans), kit fox and gray fox (Vulpes macrotis) and (Urocyon cinereoargenteus), black-tailed jackrabbit (Lepus californicus), cottontails (Sylvilagus sp.) and a variety of small mammals and birds. The proposed lease area also includes the northern shoreline of Elephant Butte Reservoir which has been designated a natural marshland area administered by the Bureau of Land Management. This marshland habitat supports rookeries of cormorants, egrets, and various other shorebirds.

The proposed lease area boundary borders the Bosque del Apache National Wildlife Refuge which supports small populations of the endangered whooping crane and Mexican duck. Numerous waterfowl and shorebirds utilize the refuge primarily as a wintering area and several species nest there. For more detailed information on the area, you may wish to contact the refuge manager, Mr. Richard Rigby, Box 278, San Antonio, New Mexico 87832 (505+835-1828).

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

The Socorro snail (Amnicola neomexicanus) has been proposed for addition to the endangered species list (Fed. Reg. 39(202); 37079; Oct. 17, 1974). This snail is only known to inhabit Sedillo and Socorro Springs which flow from the mountains about three miles west of the town of Socorro. At present both springs are capped for the town's water supply. To our knowledge, there is no record of the snail having been collected for several years, but another organism endemic to the two springs, an aquatic species of sow bug (Exosphaeroma thermophilum), is still found in one of the drains supplying original water rights to ranches in the area. This isopod is being proposed for listing by the State of New Mexico. The present status and distribution of these unique invertebrate species are not fully understood. Since their known populations are restricted to the two relatively small springs, it is possible that any geothermal development in the area could have a severe adverse impact on their continued existence.

Six vegetative types have been identified within the proposed lease area. However, riparian vegetation has not been included; it should be addressed in the EAR.

The possible impacts to wildlife and their environments that would be associated with geothermal development include toxic materials such as fuel spills, drilling muds, mud pits and/or ponding of water containing toxic pollutants. In most cases, the effect would be local and would impact non-migratory species such as small mammals whose territorial limits are often so restricted that they would be lost due to development activities or through elimination of habitat. Migratory bird species and terrestrial animals with relatively large home ranges may be attracted to toxic mud sumps and ponds; also, the movement of animals such as the mule deer and, in particular, the pronghorn could be seriously restricted by above-ground pipeline construction or other similar structures that would deter or prevent movement. Animals may also be temporarily or permanently dispersed due to the noise and human activity associated with construction of roads, pipelines, drill pads, plant sites, and powerlines.

Depending on how and where specific sites are cleared there could be beneficial effects associated with development. For example, clearing of powerline corridors through pinyon-juniper would eventually permit grass and shrub species to establish and form a desirable edge effect between two distinct plant communities. This clearing would be beneficial to those species preferring open space. In most other cases, however, clearing of large blocks of pinyon-juniper or any other loss of vegetation would be considered a loss of habitat. Without knowledge of site-specific environments and associated wildlife species, we can only generalize as to probable impacts. Assuming full development including roads, pipelines, plants, and powerlines, the overall impact on wildlife would be negative.

Impacts on aquatic environments such as the Rio Grande would depend on location of activities in relation to such environments. Activities close to the Rio Grande could, for example, accidentally introduce toxic substances and/or hot water into the river which would directly affect the survival of fish, other vertebrates, and invertebrate life; and could, depending on the type of substance introduced, affect reproduction and the overall productivity of the river for a significant time afterward both in and outside of the proposed lease area boundary. Also, erosion from disturbed soils could contribute to an already high sediment load in the Rio Grande.

With regard to your request for stipulations and mitigation measures to protect the fish and wildlife resources we suggest inclusion of the following constraints in the EAR:

- Limit the size of drill pads, roads, power plant sites, and pipeline and powerline rights-of-way to what is actually needed.

- Require the lessee to reclaim and revegetate disturbed areas with suitable plant species, preferably those native species which existed on the area prior to development, or with species that will equal or exceed the quality of pre-existing habitat.

- Require that mud pits and ponds created by development be designed and located, and be large enough, so that any overflow will be contained and prevented from entering nearby drainages or watersheds.

- Prevent extensive development in riparian areas.

- Require pipelines to be built in such a manner as to permit free movement of all wildlife species.

The above constraints on the lessee constitute our major concerns at this time. We may submit additional recommendations with our comments on the draft EAR. We appreciate the opportunity to provide our input and comments at this early stage. If you have any questions, please contact Art Kinsky at 766-3966, FTS 474-3966.

Bob Pacific

Robert Pacific

cc:
Senior Staff Assistant, FWS, OBS, Albuquerque, New Mexico
Endangered Species Coordinator, SE, Albuquerque, New Mexico

APPENDIX D

STIPULATIONS THAT MAY BE INCLUDED WITH LEASES

The following preamble will become part of all leases which contain stipulations.

"The Lessee shall comply with the following special conditions and stipulations unless they are modified by mutual agreement of the Lessee, the Geothermal Supervisor, and the BLM Authorized Officer."

1. A qualified archaeologist acceptable to the Authorized Officer (District Manager-BLM) must prepare the certified statement on archaeological values described in Section 18 of the Geothermal Resources Lease Form.

2. The Authorized Officer (District Manager-BLM) and Supervisor (USGS) retain the prerogative to require relocation of the operations to protect all archaeological values located on the leased lands, or they may require the lessee to have the archaeological site(s) excavated and salvaged by a qualified archaeologist(s) prior to proceeding with operations.

3. Existing water in stock tanks, ponds, reservoirs, creeks or streams is not available for use in any activities under this lease except as may be specifically permitted by the Bureau of Land Management (BLM) or where the lessee has water rights or the authorized use of such water rights.

4. No drilling or storage facilities would be allowed within ________ feet (__________ meters) of (live water, the reservoir, etc.) located in (legal subdivision). This distance may be modified when specifically approved in writing by the USGS Supervisor with the concurrence of the BLM Authorized Officer.

5. No occupancy or other surface disturbance would be allowed on slopes in excess of _______ percent, without written permission from the USGS Supervisor, with the concurrence of the BLM Authorized Officer.

6. "Due to environmental sensitivity, surface occupancy of (legal description) will only be allowed if the Lessee can demonstrate, by appropriate Plan of Operation to the mutual satisfaction of the Geothermal Supervisor and the BLM Authorized Officer, that surface occupancy will not unduly threaten or endanger _____________________________ ____________________ of the area."

7. In order to (minimize watershed damage, protect important seasonal wildlife habitat, etc.) exploration, drilling, and other development activity would be allowed only during the period from __________ to ___________. This limitation does not apply to maintenance and operation of producing wells. Exceptions to this limitation in any year may be specifically authorized in writing by the USGS Supervisor with the concurrence of the BLM Authorized Officer.

8. The lease is located within the White Sands Missile Range Extension Area. The Lessee or his employees would be requested to evacuate the Extension Area on those days that missiles are to be fired. This includes lands in T. 1, 2 N., R. 2, 3, 4, 5, 6, 7, 8, E.; T. 1, 2, 3, 4, 5, S.; R. 2, 3, 4, 5, 6, 7, 8, E.

9. No surface occupancy will be allowed a) south of U. S. 380, near Carthage where Petalosteum scoparium is known to exist,

   T. 5 S., R. 2 E., NMPM
   Sec. 15: All

   b) northeast cliffs of Socorro and Strawberry Peaks which is prime habitat for Silene plankii.

   T. 2 S., R. 2 W., NMPM
   Sec. 25: All

   T. 2 S., R. 1 W., NMPM
   Sec. 30: Lots 1, 2, 3, 4, N½, N½SW¼,
   SW¼SW¼,

10. No surface disturbance of Nogal Canyon North and the lands adjacent to it.

    T. 4 S., R. 1 W., NMPM
    Sec. 33: SW¼SW¼, S½SE¼,

    T. 5 S., R. 1 W., NMPM
    Sec. 4: NW¼NW¼,
    Sec. 5: S½SW¼, NE¼,

11. No surface disturbance on the Jornada Lava Flow or the lands adjacent to it.

    T. 8 S., R. 1 E., NMPM
    Sec. 20: Lots 1, 2, 3, 4, E½,
    Sec. 21: All
    Sec. 22: All

T. 8 S., R. 1 E., NMPM (continued)
Sec. 23: All
Sec. 24: All
Sec. 25: N½, SW¼, W½SE¼, SE¼SE¼,
Sec. 26: All
Sec. 27: All
Sec. 28: All
Sec. 29: Lots 1, 2, 3, 4, E½E½, NW¼NE¼,
Sec. 33. All
Sec. 34: All
Sec. 35: All

T. 8 S., R. 2 E., NMPM
Sec. 29: S½
Sec. 30: Lots 1, 2, 3, 4, SE¼NW¼, E½SW¼
Sec. 31: All

T. 9 S., R. 1 E., NMPM
Sec. 1: All
Sec. 3: All
Sec. 4: All
Sec. 5: Lots 1, 2, 3,
Sec. 9: All
Sec. 10: All
Sec. 11: All
Sec. 12: All
Sec. 13: N½,
Sec. 14: N½,
Sec. 15: N½,

T. 9 S., R. 2 E., NMPM
Sec. 5: All
Sec. 6: All
Sec. 7: All
Sec. 8: N½, SW¼, NW¼SE¼,
Sec. 17: NW¼, S½NE¼, NE¼NE¼,
Sec. 18: Lots 1, 2, NE¼, E½NW¼,

12. No surface occupancy of Torreon Springs or the lands adjacent to it.

T. 5 S., R. 2 W., NMPM
Sec. 8: Lots 1, 3, 4, N½N½, SW¼NW¼,

13. No surface occupancy of San Antonio Recreation and Public Purposes sanitary landfill site.

T. 5 S., R. 1 E., NMPM
Sec 6: S½S½N½SW¼NE¼, N½N½S½SW¼NE¼,

14. No surface occupancy of Lemitar Recreation and Public Purposes Dumpsite.

T. 2 S., R. 1 W., NMPM
Sec. 13, Lots 36, 37, 40, 41,

15. No surface occupancy on the Socorro Gun Club Recreation and Public Purposes site and ½ mile (0.8 kilometers) or more, depending on safety, behind the target area.

T. 4 S., R. 1 W., NMPM
Sec. 21: E½SW¼, W½SE¼, E½NW¼, W½NE¼,

16. No surface occupancy of the San Antonio Recreation and Public Purposes Recreation Site and the lands adjacent to it.

T. 4 S., R. 1 E., NMPM
Sec. 31: SE¼NW¼SE¼, SW¼NE¼SE¼,

17. No surface disturbance would be allowed within 300 yards (274 meters) of sites on or eligible for the National Register of Historic Places. At the present time, four sites have been identified as eligible for nomination: Johnson Hill Pueblo, Bell Mountain Site, AR-NM-02-205 and AR-NM-02-438; others may be identified in the future. In order to protect these sites, locations would not be published until a lease application is made.

18. No surface disturbance of the Soaptree Yucca Area

T. 8 S., R. 2 E., NMPM
Sec. 17: S½,
Sec. 18: S½,
Sec. 19: All
Sec. 20: All
Sec. 29: N½
Sec. 30: NE¼NW¼, NE¼,

19. No surface disturbance of Quebradas Hills

T. 3 S., R. 2 E., NMPM
Sec. 4: All
Sec. 8: SE¼,
Sec. 9: N½, SW¼,
Sec. 17: All
Sec. 20: All
Sec. 29: All

20. No surface disturbance of the 680 acres (285 hectares) of Elephant Butte Marsh and the lands adjacent to it.

T. 10 S., R. 3 W., NMPM
Sec. 20: All
Sec. 29: All

21. No surface disturbance within San Lorenzo Canyon and the lands adjacent to it.

T. 1 S., R. 1 W., NMPM
Sec. 7: Lots 1, 2, 3,

T. 1 S., R. 2 W., NMPM
Sec. 12: Lots 1, 2, 3, S½NE¼,

22. No surface disturbance of lands adjacent to the Bosque Del Apache Wildlife Refuge boundary.

T. 5 S., R. 1 W., NMPM
Sec. 13: Lots 1, 2, 3, 4, N½S½,
Sec. 14: Lots 1, 2, 3, 4, N½S½,
Sec. 15: Lots 3, 4, 5, 6, N½SE¼,

T. 5 S., R. 1 E., NMPM
Sec. 13: Lots 1, 2, 3, 4, N½S½,
Sec. 14: Lots 1, 2, 3, 4, N½S½,
Sec. 15: Lots 3, 4, 5, 6, 7, N½SE¼, NE¼SW¼,
Sec. 18: Lots 3, 4, NE¼SW¼,

T. 5 S., R. 2 E., NMPM

Sec. 18: Lots 2, 3, 4, 5, 6,
NE¼SW¼, S½NE¼,
Sec. 19: Lot 1,
Sec. 20: Lots 1, 2, 3, 4,
W½NE¼SW¼, W½SW¼SW¼,
Sec. 30: Lots 1, 2, 3, 4,
W½SE¼NE¼, W½SW¼SE¼,
Sec. 31: Lots 1, 2, 3, W½SE¼NW¼,

T. 6 S., R. 1 E., NMPM
Sec. 1: Lots 1, 2, 3, 4,
W½SW¼NE¼, W½SW¼SE¼,
Sec. 11: Lot 1,
Sec. 12: Lots 1, 2, 3,
W½SE¼NW¼, W½SW¼SW¼,
Sec. 14: Lots 1, 2, 3, 4,
W½SE¼NE¼, W½SW¼SE¼,
Sec. 22: Lots 1, 2,
Sec. 23: Lots 1, 2,
W½SE¼NW¼, NW¼SW¼, W½SW¼SW¼,
Sec. 27: Lots 1, 2, 3, 4, W½NW¼SE¼,
Sec. 34: NE¼NW¼, W½SE¼NW¼, W½SW¼SW¼,

T. 7 S., R. 1 E., NMPM
Sec. 4: Lots 1, 2, 3, 4, 5,
W½NW¼SE¼,
Sec. 8: Lots 1, 2,
Sec. 9: Lots 1, 2, W½NW¼SW¼,
Sec. 17: Lots 1, 2, 3, 4,
W½NW¼SE¼,
Sec. 19: Lots 1, 2, 3, 4,
Sec. 20: Lots 1, 2, 3,

23. No surface disturbance of the lands adjacent to Sedillo and Socorro Springs on the Socorro Grant.

T. 3 S., R. 1 W., NMPM
Sec. 21: S½,

24. No surface disturbance of, or the lands adjacent to, Amado Springs.

T. 2 S., R. 1 E., NMPM
Sec. 27: S½NE¼, N½SE¼,

25. No surface disturbance of Nogal Canyon South or the lands adjacent to it.

T. 8 S., R. 4 W., NMPM
Sec. 33: SW¼,

T. 9 S., R. 4 W., NMPM
Sec. 3: NE¼, S½S½,
Sec. 4: Lot 1,
Sec. 11: Lots 1, 2, 5, 6, NW¼,S½NE¼,
Sec. 12: SW¼, S½NW¼,

STIPULATIONS THAT MAY BE INCLUDED WITH "NOTICES OF INTENT"

A. The general environmental protection requirements of Geothermal Resource Operational Order No. 4 shall be applied to all pre-lease "Notice of Intent" activities. The terms "Permittee" and "Authorized Officer" shall be substituted for "Leasee" and "Supervisor".

B. Prior to any operations other than casual use, a cultural resource survey shall be performed by an archaeologist acceptable to the BLM Authorized Officer.

C. Existing water in stock tanks, ponds, reservoirs, creeks, or streams is not available for use in any activities under this lease except as may be specifically permitted by the Bureau of Land Management or where the lessee has water rights or the authorized use of such water rights.

D. All drill sites, roads, support facilities, structures, storage yards, and rights-of-way would be rehabilitated. The BLM may approve or prescribe construction and rehabilitation methods and practices as determined necessary to achieve desired reclamation results. Reclamation is critically site specific, therefore, special stipulations may include determination of the final topography, drainage system, revegetation methods, soil treatments and amendments, stockpiling of topsoil, segregation of spoil materials, surface manipulations, waste disposal and other practices deemed necessary to rehabilitate disturbed areas. Rehabilitation should be completed within 1 year.

E. There should be no surface disturbance of lands adjacent to Sedillo and Socorro Springs on the Socorro Grant.

T. 3 S., R. 1 W.
Sec. 21: S½

F. Disturbance of drainages and high erosion hazardous areas shall be avoided. Surface construction or land disturbance activities shall not occur within any flood plain or channel of any water course except at stream crossing, designated by the BLM. Drainages shall not be blocked nor shall the permittee cause the siltation or accumulation of debris in the drainage channels.

G. Harassing of wildlife and livestock by low flying aircraft during airborne geophysical exploration is prohibited.

H. Drill pads shall not be located closer than 300 feet (92 meters) in or adjacent to major drainage bottoms, lakes, or perennial streams without special approval of BLM.

I. Vegetation would not be removed within 300 feet (92 meters) of water (springs, reservoirs, tanks, seeps, etc.)

J. The BLM grazing permittee or lessee shall be informed of the approximate starting and completion dates of any geothermal related activity.

K. The "Notice of Intent" is located within the White Sands Missile Range Extension Area. The permittee or his employees would be requested to evacuate the Extension Area on those days that missiles are to be fired. This includes lands in T. 1, 2 N., R. 2, 3, 4, 5, 6, 7, 8 E.; T. 1, 2, 3, 4, 5 S.; R. 2, 3, 4, 5, 6, 7, 8 E.

L. All trees and brush cleared shall be stockpiled adjacent to the site. The piled vegetation shall be distributed around the pad and adjacent areas (after the disturbed area is reseeded) as directed by the responsible BLM official.

M. When surface operations are completed, overburden or other waste shall be returned to the holes, pits, and excavations, as set forth in the operating plan, except in instances where the District Manager determines that it would be desirable to use an excavation for the permanent impoundment of water or for other beneficial uses.

N. There would be no surface disturbance of isolated riparian sites that have poplars, cottonwoods, tamarisk, willow, and similar riparian vegetation.

O. Surface disturbance or intrusion would not be allowed within a buffer zone of an antelope kidding ground in (legal description).

P. All access routes, roads, and rights-of-way shall be located so as not to detract from aesthetic values (i.e., up mountain slopes along well traveled highways, etc.). Roads would be located in pipeline, or other utility or transportation corridors wherever possible.

Q. Drill pads shall not be located closer than 300 feet (92 meters) in or adjacent to major drainage bottoms, lakes, or perennial streams without special approval of BLM. (In certain areas metal tanks may be necessary to hold all drilling mud. The mud would be properly disposed of in an area designated by the BLM).

R. Geothermal related surface activity would not be allowed within approximately ¼ mile (0.4 kilometers) of cliffs, ledges, escarpments, rock outcrops, and canyon walls and rims suitable for good bird nesting, during the nesting season, from ____________ to ____________.

S. Activities employing wheeled or tracked vehicles shall be conducted in a manner suitable to the BLM Authorized Officer so as to minimize surface damage. Existing roads and trails shall be used whenever possible.

T. Noxious odors would be minimized in the vicinity of inhabited areas, as determined by the BLM Authorized Officer.

U. Prior to entry upon the land, a botanical survey shall be conducted by a BLM approved botanist to establish the presence, absence, or possible presence of threatened or endangered plants.

V. Upon completion of drilling, a sample of the reserve pit liquids would be taken by the lessee and analyzed for toxic and harmful substances. A certified analysis would be furnished to BLM as to time, location of sample, and accuracy of analysis. If the liquids are determined to be harmful to wildlife or vegetation, BLM may require that the pit be covered or fenced to protect livestock or wildlife. The fence would be built by the permittee and would be designed by the BLM as to the type of wire, height, etc.

W. No occupancy or other activity on the surface of (legal subdivision) is allowed under this permit.

X. The ____________ (trail/road) would not be used as an access road for activities on this permit.

SPECIAL STIPULATIONS FOR
SHALLOW TEMPERATURE GRADIENT HOLES DRILLED
UNDER BLM "NOTICE OF INTENT" PRELEASE EXPLORATION PERMITS

AA. Holes for measuring temperature gradients to determine heat flow shall be limited to a depth of 152 meters (500 feet), unless otherwise authorized.

BB. Inlet and outlet temperatures shall be recorded at frequent time intervals during drilling operations in temperature gradient holes. Normally, hourly or 9 meter (30 feet) intervals.

CC. If flow line mud temperature should reach 52°C. (125°F.) without special cooling, further drilling shall stop immediately and the hole will be either:
- (a) completed as an observation hole by running steel tubing to the desired depth and filling the annulus with drilling mud from total depth to 3 meters (10 feet) and with cement 10 feet to the surface.
- (b) abandoned by filling the hole with drilling mud to within 3 meters (10 feet) of the surface and with cement to the surface.
- (c) equipped with mud cooling and wellhead control equipment, to maintain the mud returns temperature at or below 52°C. (125°F.). If approved by the Authorized Officer, who may consult with the Area Geothermal Supervisor, drilling may then be resumed.
- (d) or, if water is encountered of sufficiently good quality that it can be beneficially used for domestic, agricultural, or wildlife management purposes, then, with the concurrence of the permittee and provided that, in the opinion of the Area Geothermal Supervisor, such action is not in conflict with geothermal regulatory requirements, the BLM may acquire the well for the fair market salvage value of the casing. If the government acquires the well, the permittee shall be relieved of all further responsibility and liability for the well.

DD. If flowing steam or hot water 65°C. (150°F.) is encountered, further drilling shall stop immediately and the hole will be either (a) completed as an observation hole using steel tubing and circulating cement from total depth to surface or (b) abandoned by plugging with cement from total depth to surface.

Exceptions will be allowed only with specific permission from the Authorized Officer, who may consult with the Area Geothermal Supervisor.

EE. If cold flowing artesian water is encountered, hole will be completed as in (DD) above, except that plastic tubing may be used.

If conditions outlined in either (CC), (DD) or (EE) above are encountered, the Authorized Officer shall be notified immediately.

FF. The operator shall submit the following information with the "Notice of Intent" (Form 3200-9), (a) the approximate location to the nearest 30 meters (100 feet) from some identifiable marker or object within a section and hole number or designation of each proposed hole and order of drilling; (b) the type and size of drilling rig; (c) the proposed drilling program including: drilling method (auger, cable, rotary with mud or air) and the approximate depth, casing and wellhead design; (d) the type of drilling sump and proposed method of sump abandonment; (e) the approximate time the holes are expected to be used for observation; and (f) the proposed method of abandonment.

GG. All changes of location or added wells must be approved by the Authorized Officer who may consult with the Supervisor.

HH. Locations proposed in natural thermal areas, within 460 meters (1500 feet) radius of known hot springs, fumaroles, or other surface geothermal indicia or in areas of known artesian water flow, will require a drilling program for each hole, approved by the Authorized Officer, who may consult with the Area Geothermal Supervisor. Such holes may require special drilling and completion techniques (such as cemented surface casing and simple bag packer blowout preventers) to safely control formations containing geothermal resources which may be penetrated.

II. Holes shall be completed for observation purposes in a manner which shall allow satisfactory subsequent abandonment. Unless otherwise required, this will normally mean cementing the annular area (between the tubing and the hole wall) from 10 feet to the surface.

JJ. Holes shall be abandoned in a manner that will prevent subsurface interzonal migration of fluids and surface leakage. As a minimum, the top 3 meters (10 feet) of tubing should be filled with cement. Tubing shall be cut off at ground level or as directed by the Authorized Officer.

KK. The Notice of Completion of Geothermal Resource Exploration Operations (Form 3200-10), as required under Condition 5 of this permit, shall be submitted in duplicate and shall contain, among other items, the following information for each hole drilled:

- (a) Final hole designation and location.
- (b) A drillers log noting water table, fluid and/or mineral contents of identifiable formation intervals.
- (c) Method of completion, cementing, and casing and/or tubing with wellhead components. This may be presented by engineering drawings.
- (d) Details of abandonment or current status of the well.
- (e) Any information on drilling difficulties or unusual circumstances encountered which would be helpful in assuring future safety of operations or protection of the environment in the area concerned.

LL. Drilling fluids or cuttings shall not be discharged onto the surface where such discharge will contaminate lakes and perennial or intermittent streams. Excavated pits or sumps used in drilling will be backfilled as soon as practicable and restored to conform with the original topography.

MM. Unless otherwise authorized, unattended sumps shall be fenced to protect domestic stock or wildlife.

NN. Applicant shall contact appropriate BLM district office prior to actual entry upon the land.

STIPULATIONS THAT MAY BE INCLUDED WITH "PLANS OF OPERATION" BEFORE SURFACE DISTURBING ACTIVITIES CAN TAKE PLACE

a. Prior to entry upon the leased land for any purpose other than "casual use", as defined in 43 CFR 3209.0-5(d), a botanical survey shall be conducted by a BLM approved botanist to establish the presence, absence, or possible presence of threatened or endangered plants.

b. Harassing of wildlife and livestock by low flying aircraft during airborne geophysical exploration is prohibited.

c. Drill pads shall not be located closer than 300 feet (92 meters) in or adjacent to major drainage bottoms, lakes, or perennial streams without special approval of BLM.

d. Vegetation would not be removed within 300 feet (92 meters) of water (springs, reservoirs, tanks, seeps, etc.)

e. Construction of roads including culverts, turnouts, ditches, or waterbars would be done according to BLM specifications.

f. Disturbance of drainages and high erosion hazardous areas shall be avoided. Surface construction or land disturbance activities shall not occur within any flood plain or channel of any water course except at stream crossing, designated by the BLM. Drainages shall not be blocked nor shall the lessee cause the siltation or accumulation of debris in the drainage channels.

g. Noxious odors would be minimized in the vicinity of inhabited areas, as determined by the BLM Authorized Officer.

h. The construction of all new roads and trails necessary for exploration or development activities shall receive appropriate approval prior to construction by the BLM Authorized Officer or the USGS Supervisor. They may determine the location and set forth the road standards and construction methods employed. Maintenance of such roads shall be the responsibility of the lessee unless otherwise approved.

i. Visual contrast ratings (BLM Manual 6320) would be completed on proposed developments, prior to any surface disturbance. All operations would comply with BLM visual resource management requirements.

j. Fences, pipelines, and other structures more than 1 mile (1.6 kilometers) in length, shall be constructed to allow antelope, deer, and other animals free movement as determined by the BLM Authorized Representative.

k. All geothermal related surface activity would be excluded from approximately 100 yards (92 meters) of brushy arroyos and draws.

l. No clearing of ground cover for power transmission lines, except for tower or pole pads, shall be allowed.

m. All disturbed areas to within 20 feet (6 meters) on each side of any production structure would be restored to original or better condition as determined by the BLM Authorized Officer.

n. When surface operations are completed, overburden or other waste shall be returned to the holes, pits, and excavations, as set forth in the operating plan, except in instances where the District Manager determines that it would be desirable to use an excavation for the permanent impoundment of water or for other beneficial uses.

o. To the extent possible, locate sites along the tops of stable ridges or in bedrock cuts along spur ridges. Wider valley bottoms with a low potential for flooding and slumping would also be suitable.

p. On hillside alignments, slope the road surface into the hillside. Seed all fill slopes, except those comprised of hard, gravel-sized or larger rock fragments, prior to the first rains and apply mulch and fertilizers as necessary.

q. No placing of large volumes of soil and rock spoilage, from site construction, on active landslides or unstable locations. It may be acceptable to place spoil (excess soil and rock) on large, dormant, or static slides. The feasibility of this would have to be considered on a site-by-site basis. Spoil should not be permanently stored on steep side slopes. Temporary side slope storage may be acceptable, but suitability must be determined on a site-by-site basis. The determination, acceptability and suitability will be made by the BLM Authorized Officer.

r. Specific slope design would be required for the pad to minimize accelerated erosion and water runoff. Contours are also required on the pad to reduce erosion.

s. Whenever possible, avoid steep side slopes underlain by deep colluvium and/or weak bedrock mantle. Such slopes are nearly always more susceptible to damaging landslides.

t. Where possible, locate well sites on those portions of the pad which have been graded into bedrock, rather than on those portions of the pad which are constructed of fill. This would lessen the possibility of damage to well casing by post-construction ground failures.

u. All trees and brush cleared from the drill site shall be stockpiled adjacent to the site. The piled vegetation shall be distributed around the pad and adjacent areas (after the disturbed area is reseeded) as directed by the responsible BLM Official.

v. Geothermal related surface activity would not be allowed within approximately ¼ mile (0.4 kilometers) of cliffs, ledges, escarpments, rock outcrops, and canyon walls and rims suitable for good bird nesting, during the nesting season.

w. There would be no surface disturbance of isolated riparian sites that have poplars, cottonwoods, tamarisk, willow, and similar riparian vegetation.

x. Surface disturbance or intrusion would not be allowed within a mile (1.6 kilometers) buffer zone of an antelope kidding ground.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Notice Number

NOTICE OF INTENT TO CONDUCT GEOTHERMAL RESOURCE EXPLORATION OPERATIONS

Applicant(s)	Address *(include zip code)*
Operator	Address *(include zip code)*
Contractor(s)	Address *(include zip code)*

hereby apply for authorization to conduct exploration operations pursuant to the provisions of 43 CFR 3209 now or hereafter in force across and upon the following-described lands *(give description of lands by township, attach map or maps showing lands to be entered or affected)*

Type of operations to be conducted *(give brief description)*

Exploration operations will be conducted during the period *(date)* from to

Attached ☐ $ Surety bond ☐ Rider to Nationwide bond ☐ Rider to Statewide bond ☐ Bond to be furnished

Upon completion of exploration operations the undersigned agrees to notify the Authorized Officer that authorized exploration operations have been completed in conformance with the general and special terms and stipulations of the notice.

The undersigned hereby agrees (1) that he will not enter upon the described land until he has been informed in writing whether there are special stipulations applicable to his Notice of Intent, as to either time or method of operation or otherwise, and, if there are such stipulations, what those stipulations are, (2) that he will comply with those special stipulations, if any; and (3) that he will not enter upon the described lands until his entry has been approved by the Authorized Officer.

The undersigned agrees to be bound by the terms and conditions of this notice to conduct exploration operations when approved by the Authorized Officer.

The undersigned agrees that the filing of this *Notice* under the regulations (43 CFR Subpart 3209) does not vest or confer any preference right to a geothermal resources lease.

The undersigned agrees further that all exploration operations shall be conducted pursuant to the following terms and conditions:

1. Exploration operations shall be conducted in compliance with all Federal, State, and local laws, ordinances, or regulations which are applicable to the area of operations including, but not limited to, those pertaining to fire, sanitation, conservation, water pollution, fish, and game. All operations hereunder shall be conducted in a prudent manner.
2. Due care shall be exercised in protecting the described lands from damage. All necessary precautions shall be taken to avoid any damage other than normal wear and tear to improvements on the land including, but not limited to, gates, bridges, roads, culverts, cattle guards, fences, dams, dikes, vegetative cover, improvements, stock watering, and other facilities.
3. All drill holes shall be capped when not in use and appropriate procedures shall be taken to protect against hazards in order to protect the lives, safety, or property of other persons or of wildlife and livestock.
4. All vehicles shall be operated at a reasonable rate of speed and, in the operation of vehicles, due care shall be taken to safequard livestock and wildlife in the vicinity of operations. Existing roads and trails shall be used wherever possible. If new roads and trails are to be constructed, the Authorized Officer must be consulted prior to construction as to location and specifications. Reclamation and/or reseeding of new roads and trails shall be made as requested by the Authorized Officer.
5. Upon expiration, conclusion, or abandonment of operations conducted pursuant to this *Notice*, all equipment shall be removed from the land, and the land shall be restored as nearly as practicable to its original condition by such measures as the Authorized Officer may specify. All geophysical holes shall be safely plugged. The Authorized Officer shall be furnished a *Notice of Completion of Geothermal Resource Exploration Operations* (Form 3200–3) immediately upon cessation of all such operations and shall be further informed of the completion of reclamation work as soon as possible.
6. Location and depth of water sands encountered shall be disclosed to the Authorized Officer.

7. Operator shall contact the Authorized Officer, prior to actual entry upon the land in order to be appraised of practices which shall be followed or avoided in the conduct of exploration operations pursuant to the terms of this *Notice* and applicable regulations. Operator will conduct no operations on the land unless the attached bond is in good standing.

8. Due care shall be exercised to avoid scarring or removal of ground vegetative cover.

9. All operations shall be conducted in such a manner to avoid (a) blockage of any drainage systems; (b) changing the character, or causing the pollution or siltation of rivers, streams, lakes, ponds, waterholes, seeps, and marshes; and (c) damaging fish and wildlife resources or habitat. Cuts or fills causing any of the above-mentioned problems will be repaired immediately in accordance with specifications of the Authorized Officer.

10. Vegetation shall not be disturbed within 300 feet of waters designated by the Authorized Officer, except at approved stream crossings.

11. Surface damage which induces soil movement and/or water pollution shall be subject to corrective action as required by the Authorized Officer.

12. Trails and campsites shall be kept clean. All garbage and foreign debris shall be eliminated as required by the Authorized Officer.

13. Operator shall protect all survey monuments, witness corners, reference monuments, and bearing trees against destruction, obliteration, or damage. He shall, at his expense reestablish damaged, destroyed, or obliterated monuments and corners, using a licensed surveyor, in accordance with Federal survey procedures. A record of the reestablishment shall be submitted to the Authorized Officer.

14. Operator shall make every reasonable effort to prevent, control, or suppress any fires started by the operator, and to report, as soon as possible, to the Authorized Officer location and size of fires, and assistance needed to suppress such fires. Operator shall inform the Authorized Officer as soon as possible of all fires, regardless of location, noted, or suppressed by independent action.

15. No work shall be done within one-half mile of a developed recreation site without specific written authority from the Authorized Officer. Any travel within one-half mile of a recreation site shall be over existing roads or trails.

16. Use of explosives within one-half mile of designated waters is prohibited unless approved, in writing, by the Authorized Officer.

17. If operations conducted under the provisions of this *Notice* causes any damage to the surface of the national resource lands, such as, but not limited to, soil erosion, pollution of water, injury or destruction of livestock or wildlife, or littering, operator shall, within 48 hours, file with the Authorized Officer a map showing exact location of such damage and a written report containing operator's plans for correcting or minimizing damage, if possible.

18. Violation of, or failure to comply with any of these terms and conditions shall result in immediate shutdown of field operations until deficiency is corrected. Failure to correct deficiency within the time period allowed by the Authorized Officer shall result in forfeiture of bond.

19. The Bureau of Land Management reserves the right to close any area to operators in periods of fire danger or when irreparable damage to natural resources is imminent.

20. Contractor shall be liable for assuring compliance with all terms and conditions of this *Notice* and all actions of his designated operator, agents, and employees.

21. Where continuation of the operation will result in irreparable damage to the land and other natural resources this *Notice* will be immediately cancelled by the Authorized Officer.

22. Special Stipulations:

(Signature of Applicant) (Date) (Signature of Operator) (Date)

We hereby agree to the special stipulations added and made a part of this *Notice* to conduct exploration operations.

(Signature of Holder of Notice) (Date) (Signature of Operator) (Date)

I hereby approve this *Notice* to conduct exploration operations.

(Signature of Authorized Officer) (Title) (Date)

GPO 851-317

Form 3200-21
(May 1974)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

GEOTHERMAL RESOURCES LEASE

☐ Competitive ☐ Noncompetitive

Serial Number

USGS – KGRA Determination:

In consideration of the terms and conditions contained herein, and the grant made hereby, this lease is entered into by the UNITED STATES OF AMERICA (hereinafter called the "Lessor"), acting through the Bureau of Land Management (hereinafter called the "Bureau") of the Department of the Interior (hereinafter called the "Department"), and

(hereinafter called the ("Lessee").

This lease is made pursuant to the Geothermal Steam Act of 1970 (84 Stat. 1566; 30 U.S.C. 1001–1025) (hereinafter called "the Act") to be effective on (hereinafter called the "effective date"). It is subject to all the provisions of the Act and to all the terms, conditions, and requirements of (a) all regulations promulgated by the Secretary of the Interior (hereinafter called "the Secretary") in existence upon the effective date, specifically including, but not limited to, 43 CFR Parts 3000 and 3200 and 30 CFR Parts 270 and 271, (b) all geothermal resources operational orders (hereinafter called "GRO orders") issued pursuant thereto, all of which are incorporated herein and by reference made a part hereof, and (c) any regulations hereafter issued by the Secretary (except those inconsistent with any specific provisions of this lease other than regulations incorporated herein by reference) all of which shall be, upon their effective date, incorporated herein and, by reference, made a part hereof.

Sec. 1. GRANT – The Lessor hereby grants and leases to the Lessee the exclusive right and privilege to drill for, extract, produce, remove, utilize, sell, and dispose of geothermal steam and associated geothermal resources, (hereinafter called "geothermal resources"), in or under the following described lands situated within the County of

State of :

National Resource Lands	Acquired Lands
T. ; R. ; Meridian	T. ; R. ; Meridian
Total Area	Total Area

Containing acres (hereinafter called the "leased area" or "leased lands"), together with:

(a) The nonexclusive right to conduct within the leased area geological and geophysical exploration in accordance with applicable regulations; and

(b) The right to construct or erect and to use, operate, and maintain within the leased area, together with ingress and egress thereupon all wells, pumps, pipes, pipelines, buildings, plants, sumps, brine pits, reservoirs, tanks, waterworks, pumping stations, roads, electric power generating plants, transmission lines, industrial facilities, electric, telegraph or telephone lines, and such other works and structures and to use so much of the surface of the land as may be necessary or reasonably convenient for the production, utilization, and processing of geothermal resources or to the full enjoyment of the rights granted by this lease, subject to compliance with applicable laws and regulations; *Provided that*, although the use of the leased area for an electric power generating plant or transmission facilities or a commercial or industrial facility is authorized hereunder, the location of such facilities and the terms of occupancy therefor shall be under separate instruments issued under any applicable laws and regulations; and

(c) The nonexclusive right to drill potable water wells in accordance with state water laws within the leased area and to use the water produced therefrom for operations on the leased lands free of cost, provided that such drilling and development are conducted in accordance with procedures approved by the Supervisor of the Geological Survey (hereinafter called "Supervisor"); and

(d) The right to convert this lease to a mineral lease under the Mineral Leasing Act of February 25, 1920, as amended, and supplemented (30 U.S.C. 181–287) or under the Mineral Leasing Act for Acquired Lands (30 U.S.C. 351–359), whichever is appropriate, if the leasehold is primarily valuable for the production of one or more valuable by-products which are leasable under those statutes, and the lease is incapable of commercial production or utilization of geothermal steam: *Provided that*, an application is made therefor prior to the expiration of the lease extension by reason of by-product production as hereinafter provided, and subject to all the terms and conditions of said appropriate Acts. The Lessee is also granted the right to locate mineral deposits under the mining laws (30 U.S.C. 21–54), which would constitute by-products if commercial production or utilization of geothermal steam continued, but such a location to be valid must be completed within ninety (90) days after the termination of this lease. Any conversion of this lease to a mineral lease or a mining claim is contingent on the availability of such lands for this purpose at the time of the conversion. If the lands are withdrawn or acquired in aid of a function of any Federal Department or agency, the mineral lease or mining claim shall be subject to such additional terms and conditions as may be prescribed by such Department or agency for the purpose of making operations thereon consistent with the purposes for which these lands are administered; and

(e) The right, without the payment of royalties hereunder, to reinject into the leased lands geothermal resources and condensates to the extent that such resources and condensates are not utilized, but their reinjection is necessary for operations under this lease in the recovering or processing of geothermal resources. If the Lessee, pursuant to any approved plan, disposes of the unusable brine and produced waste products into underlying formations, he may do so without the payment of royalties.

Sec. 2. TERM

(a) This lease shall be for a primary term of ten (10) years from the effective date and so long thereafter as geothermal steam is produced or utilized in commercial quantities but shall in no event continue for more than forty (40) years after the end of the primary term. However, if at the end of that forty-year period geothermal steam is being produced or utilized in commercial quantities, and the leased lands are not needed for other purposes, the Lessee shall have a preferential right to a renewal of this lease for a second forty-year term in accordance with such terms and conditions as the Lessor deems appropriate.

(b) If actual drilling operations are commenced on the leased lands or under an approved plan or agreement on behalf of the leased lands prior to the end of the primary term, and are being diligently prosecuted at the end of the primary term, this lease shall be extended for five (5) years and so long thereafter, but not more than thirty-five (35) years, as geothermal steam is produced or utilized in commercial quantities. If at the end of such extended term geothermal steam is being produced or utilized in commercial quantities, the Lessee shall have a preferential right to a renewal for a second term as in (a) above.

(c) If the Lessor determines at any time after the primary term that this lease is incapable of commercial production and utilization of geothermal steam, but one or more valuable by-products are or can be produced in commercial quantities, this lease shall be extended for so long as such by-products are produced in commercial quantities but not for more than five (5) years from the date of such determination.

Sec. 3. RENTALS AND ROYALTIES

(a) *Annual Rental* – For each lease year prior to the commencement of production of geothermal resources in commercial quantities on the leased lands, the Lessee shall pay the Lessor on or before the anniversary date of the lease a rental of $ for each acre or fraction thereof.

(b) *Escalating Rental* – Beginning with the sixth lease year and for each year thereafter until the lease year beginning on or after the commencement of production of geothermal resources in commercial quantities, the Lessee shall pay on or before the anniversary date of the lease an escalated rental in an amount per acre or fraction thereof equal to the rental per acre for the preceding year and an additional sum of one (1) dollar per acre or fraction thereof. If the lease is extended beyond ten (10) years for reasons other than the commencement of production of geothermal resources in commercial quantities, the rental for the eleventh year and for each lease year thereafter until the lease year beginning on or after the commencement of such production will be the amount of rental for the tenth lease year. If any expenditures are made in any lease year for diligent exploration on the leased lands in excess of the minimum required expenditures for that year, the excess may be credited against any rentals in excess of $ per acre or fraction thereof due the Lessor for that or any future year.

(c) *Royalty* – On or before the last day of the calendar month after the month of commencement of production in commercial quantities of geothermal resources and thereafter on a monthly basis, the Lessee shall pay to the Lessor:

(1) A royalty of percent on the amount or value of steam, or any other form of heat or other associated energy produced, processed, removed, sold, or utilized from this lease or reasonably susceptible to sale or utilization by the Lessee.

(2) A royalty of percent of the value of any by-product derived from production under this lease, produced, processed, removed, sold, or utilized from this lease or reasonably susceptible of sale or utilization by the Lessee, except that as to any by-product which is a mineral named in Sec. 1 of the Mineral Leasing Act of February 25, 1920, as amended, (30 U.S.C. 181), the rate of royalty for such mineral shall be the same as that provided in that statute and the maximum rate of royalty for such mineral shall not exceed the maximum royalty applicable under that statute.

(3) A royalty of percent of the value of commercially demineralized water which has been produced from the leased lands, and has been sold or utilized by the Lessee or is reasonably susceptible of sale or utilization by the Lessee. In no event shall the Lessee pay to the Lessor, for the lease year beginning on or after the commencement of production in commercial quantities on the leased lands or any subsequent lease year, a royalty of less than two (2) dollars per acre or fraction thereof. If royalty paid on production during the lease year has not satisfied this requirement, the Lessee shall pay the difference on or before the expiration date of the lease year for which it is paid.

(d) *Waiver and Suspension of Rental and Royalties* – Rentals or royalties may be waived, suspended, or reduced pursuant to the applicable regulations on the entire leasehold or any portion thereof in the interest of conservation or for the purpose of encouraging the greatest ultimate recovery of geothermal resources if the Lessor determines that it is necessary to do so to promote such development, or because the lease cannot be successfully operated under the terms fixed herein.

(e) *Undivided Fractional Interests* – Where the interest of the Lessor in the geothermal resources underlying any tract or tracts described in Sec. 1 is an undivided fractional interest, the rentals and royalties payable on account of each such tract shall be in the same proportion to the rentals and royalties provided in this lease as the individual fractional interest of the Lessor in the geothermal resources underlying such tract is to the full fee interest.

(f) *Readjustments* – Rentals and royalties hereunder may be readjusted in accordance with the Act and regulations to rates not in excess of the rates provided therein, and at not less than twenty (20) year intervals beginning thirty-five (35) years after the date geothermal steam is produced from the lease as determined by the Supervisor.

Sec. 4. PAYMENTS – It is expressly understood that the Secretary may establish the values and minimum values of geothermal resources to compute royalties in accordance with the applicable regulations. Unless otherwise directed by the Secretary, all payments to the Lessor will be made as required by the regulations. If there is no well on the leased lands capable of producing geothermal resources in commercial quantities, the failure to pay rental on or before the anniversary date shall cause the lease to terminate by operation of law except as provided by Sec. 3244.2 of the regulations. If the time for payment falls on a day on which the proper office to receive payment is closed, payment shall be deemed to be made on time if made on the next official working day.

Sec. 5. BONDS – The Lessee shall file with the Authorized Officer of the Bureau (hereinafter called the "Authorized Officer") shall maintain at all times the bonds required under the regulations to be furnished as a condition to the issuance of this lease or prior to entry on the leased lands in the amounts established by the Lessor and to furnish such additional bonds or security as may be required by the Lessor upon entry on the lands or after operations or production have begun.

Sec. 6. WELLS

(a) The Lessee shall drill and produce all wells necessary to protect the leased land from drainage by operations on lands not the property of the Lessor, or other lands of the Lessor leased at a lower royalty rate, or on lands as to which royalties and rentals are paid into different funds from those into which royalties under this lease are paid. However, in lieu of any part of such drilling and production, with the consent of the Supervisor, the Lessee may compensate the Lessor in full each month for the estimated loss of royalty through drainage in the amount determined by said Supervisor.

(b) At the Lessee's election, and with the approval of the Supervisor, the Lessee shall drill and produce other wells in conformity with any system of well spacing or production allotments affecting the field or area in which the leased lands are situated, which is authorized by applicable law.

(c) After due notice in writing, the Lessee shall diligently drill and produce such wells as the Supervisor shall require so that the leased lands may be properly and timely developed and for the production of geothermal steam and its by-products, including commercially demineralized water for beneficial uses in accordance with applicable state laws. However, the Supervisor may waive or modify the requirements of this subparagraph (c) in the interest of conservation of natural resources or for economic feasibility or other reasons satisfactory to him. If the products or by-products of geothermal production from wells drilled on this lease are susceptible of producing commercially demineralized water for beneficial uses, and a program therefor is not initiated with due diligence, the Lessor may at its option elect to take such products or by-products and the Lessee shall deliver all or any portion thereof to the Lessor at any point in the Lessee's geothermal gathering or disposal system without cost to the Lessee, if the Lessee's activities, under the lease, would not be impaired and such delivery would otherwise be consistent with field and operational requirements. The retention of this option by the Lessor shall in no way relieve the Lessee from the duty of producing commercially demineralized water where required to do so by the Lessor, except when the option is being exercised and then only with respect to wells where it is being exercised, or limit the Lessor's right to take any action under Sec. 25 to enforce that requirement.

Sec. 7. INSPECTION – The Lessee shall keep open at all reasonable times for the inspection of any duly authorized representative of the Lessor the leased lands and all wells, improvements, machinery, and fixtures thereon and all production reports, maps, records, books, and accounts relative to operations under the lease, and well logs, surveys, or investigations of the leased lands.

Sec. 8. CONDUCT OF OPERATIONS – The Lessee shall conduct all operations under this lease in a workmanlike manner and in accordance with all applicable statutes, regulations, and GRO orders, and all other appropriate directives of the Lessor to prevent bodily injury, danger to life or health, or property damage, and to avoid the waste of resources, and shall comply with all requirements which are set forth in 43 CFR Group 3200, including, but not limited to, Subpart 3204, or which may be prescribed by the Lessor pursuant to the regulations, and with the special stipulations which are attached to the lease, all of which are specifically incorporated into this lease. A breach of any term of this lease, including the stipulations attached hereto, will be subject to all the provisions of this lease with respect to remedies in case of default. Where any stipulation is inconsistent with a regular provision of this lease, the stipulation shall govern.

Sec. 9. INDEMNIFICATION

(a) The Lessee shall be liable to the Lessor for any damage suffered by the Lessor in any way arising from or connected with the Lessee's activities and operations conducted pursuant to this lease, except where damage is caused by employees of the Lessor acting within the scope of their authority.

(b) The Lessee shall indemnify and hold harmless the Lessor from all claims arising from or connected with the Lessee's activities and operations under this lease.

(c) In any case where liability without fault is imposed on the Lessee pursuant to this section, and the damages involved were caused by the action of a third party, the rules of subrogation shall apply in accordance with the law of the jurisdiction where the damage occurred.

Sec. 10. CONTRACTS FOR SALE OR DISPOSAL OF PRODUCTS – The Lessee shall file with the Supervisor not later than thirty (30) days after the effective date thereof any contract, or evidence of other arrangement for the sale or disposal of geothermal resources.

Sec. 11. ASSIGNMENT OF LEASE OR INTEREST THEREIN – Within ninety (90) days from the date of execution thereof, the Lessee shall file for approval by the Authorized Officer any instruments of transfer made of this lease or of any interest therein, including assignments of record title and working or other interests.

Sec. 12. REPORTS AND OTHER INFORMATION – At such times and in such form as the Lessor may prescribe, the Lessee shall comply with all reporting requirements of the geothermal resources leasing, operating, and unit regulations and shall submit quarterly reports containing the data which it has collected through the monitoring of air, land, and water quality and all other data pertaining to the effect on the environment by operations under the lease. The Lessee shall also comply with such other reporting requirements as may be imposed by the Authorized Officer or the Supervisor. The Lessor may release to the general public any reports, maps, or other information submitted by the Lessee except geologic and geophysical interpretations, maps, or data subject to 30 CFR 270.79 or unless the Lessee shall designate that information as proprietary and the Supervisor or the Authorized Officer shall approve that designation.

Sec. 13. DILIGENT EXPLORATION – In the manner required by the regulations, the Lessee shall diligently explore the leased lands for geothermal resources until there is production in commercial quantities applicable to this lease. After the fifth year of the primary term the Lessee shall make at least the minimum expenditures required to qualify the operations on the leased lands as diligent exploration under the regulations.

Sec. 14. PROTECTION OF THE ENVIRONMENT (LAND, AIR AND WATER) AND IMPROVEMENTS – The Lessee shall take all mitigating actions required by the Lessor to prevent: (a) soil erosion or damage to crops or other vegetative cover on Federal or non-Federal lands in the vicinity; (b) the pollution of land, air, or water; (c) land subsidence, seismic activity, or noise emissions; (d) damage to esthetic and recreational values; (e) damage to fish or wildlife or their habitats; (f) damage to or removal of improvements owned by the United States or other parties; or (g) damage to or destruction or loss of fossils, historic or prehistoric ruins, or artifacts. Prior to the termination of bond liability or at any other time when required and to the extent deemed necessary by the Lessor, the Lessee shall reclaim all surface disturbances as required, remove or cover all debris or solid waste, and, so far as possible, repair the offsite and onsite damage caused by his activity or activities incidental thereto, and return access roads or trails and the leased lands to an acceptable condition including the removal of structures, if required. The Supervisor or the Authorized Officer shall prescribe the steps to be taken by Lessee to protect the surface and the environment and for the restoration of the leased lands and other lands affected by operations on the leased lands and improvements thereon, whether or not the improvements are owned by the United States. Timber or mineral materials may be obtained only on terms and conditions imposed by the Authorized Officer.

Sec. 15. WASTE – The Lessee shall use all reasonable precautions to prevent waste of natural resources and energy, including geothermal resources, or of any minerals, and to prevent the communication of water or brine zones with any oil, gas, fresh water, or other gas or water bearing formations or zones which would threaten destruction or damage to such deposits. The Lessee shall monitor noise, air, and water quality conditions in accordance with any orders of the Supervisor.

Sec. 16. MEASUREMENTS – The Lessee shall gauge or otherwise measure all production, sales, or utilization of geothermal resources and shall record the same accurately in records as required by the Supervisor. Reports on production, sales, or utilization of geothermal resources shall be submitted in accordance with the terms of this lease and the regulations.

Sec. 17. RESERVATIONS TO LESSOR – All rights in the leased area not granted to the Lessee by this lease are hereby reserved to the Lessor. Without limiting the generality of the foregoing such reserved rights include:

(a) *Disposal* – The right to sell or otherwise dispose of the surface of the leased lands or any resource in the leased lands under existing laws, or laws hereafter enacted, subject to the rights of the Lessee under this lease;

(b) *Rights-of-way* – The right to authorize geological and geophysical explorations on the leased lands which do not interfere with or endanger actual operations under this lease, and the right to grant such easements or rights-of-way for joint or several use upon, through or in the leased area for steam lines and other public or private purposes which do not interfere with or endanger actual operations or facilities constructed under this lease;

(c) *Mineral Rights* – The ownership of and the right to extract oil, hydrocarbon gas, and helium from all geothermal steam and associated geothermal resources produced from the leased lands;

(d) *Casing* – The right to acquire the well and casing at the fair market value of the casing where the Lessee finds only potable water, and such water is not required in lease operations; and

(e) *Measurements* – The right to measure geothermal resources and to sample any production thereof.

Sec. 18. ANTIQUITIES AND OBJECTS OF HISTORIC VALUE – The Lessee shall immediately bring to the attention of the Authorized Officer any antiquities or other objects of historic or scientific interest, including but not limited to historic or prehistoric ruins, fossils, or artifacts discovered as a result of operations under this lease, and shall leave such discoveries intact. Failure to comply with any of the terms and conditions imposed by the Authorized Officer with regard to the preservation of antiquities may constitute a violation of the Antiquities Act (16 U.S.C. 431-433). Prior to operations, the Lessee shall furnish to the Authorized Officer a certified statement that either no archaeological values exist or that they may exist on the leased lands to the best of the of the Lessee's knowledge and belief and that they might be impaired by geothermal operations. If the Lessee furnishes a statement that archaeological values may exist where the land is to be disturbed or occupied, the Lessee will engage a qualified archaeologist, acceptable to the Authorized Officer, to survey and salvage, in advance of any operations, such archaeological values on the lands involved. The responsibility for the cost for the certificate, survey, and salvage will be borne by the Lessee, and such salvaged property shall remain the property of the Lessor or the surface owner.

Sec. 19. DIRECTIONAL DRILLING – A directional well drilled under the leased area from a surface location on nearby land not covered by the lease shall be deemed to have the same effect for all purposes of this lease as a well drilled from a surface location on the leased area. In such circumstances, drilling shall be considered to have been commenced on the nearby land for the purposes of this lease, and production of geothermal resources from the leased area through any directional well located on nearby land, or drilling or reworking of any such directional well shall be considered production or drilling or reworking operations (as the case may be) on the leased area for all purposes of this lease. Nothing contained in this section shall be construed as granting to the Lessee any right in any land outside the leased area.

Sec. 20. OVERRIDING ROYALTIES – The Lessee shall not create overriding royalties of less than one-quarter (1/4) of one percent of the value of output nor in excess of 50 percent of the rate of royalty due to the Lessor specified in Sec. 3 of this lease except as otherwise authorized by the regulations. The Lessee expressly agrees that the creation of any overriding royalty which does not provide for a prorated reduction of all overriding royalties so that the aggregate rate of royalties does not exceed the maximum rate permissible under this section, or the failure to suspend an overriding royalty during any period when the royalties due to the Lessor have been suspended pursuant to the terms of this lease, shall constitute a violation of the lease terms.

Sec. 21. READJUSTMENT OF TERMS AND CONDITIONS – The terms and conditions of this lease other than those related to rentals and royalties may be readjusted in accordance with the Act at not less than ten-year intervals beginning ten (10) years after the date geothermal steam is produced from the leased premises as determined by the Supervisor.

Sec. 22. COOPERATIVE OR UNIT PLAN – The Lessee agrees that it will on its own, or at the request of the Lessor where it is determined to be necessary for the conservation of the resource or to prevent the waste of the resource, subscribe to and operate under any reasonable cooperative or unit plan for the development and operation of the area, field, or pool, or part thereof embracing the lands subject to this lease as the Secretary may determine to be practicable and necessary or advisable in the interest of conservation. In the event the leased lands are included within a unit, the terms of this lease shall be deemed to be modified to conform to such unit agreement. Where any provision of a cooperative or unit plan of development which has been approved by the Secretary, and which by its terms affects the leased area or any part thereof, is inconsistent with a provision of this lease, the provisions of such cooperative or unit plan shall govern.

Sec. 23. RELINQUISHMENT OF LEASE – The Lessee may relinquish this entire lease or any officially designated subdivision of the leased area in accordance with the regulations by filing in the proper BLM office a written relinquishment, in triplicate, which shall be effective as of the date of filing. No relinquishment of this lease or any portion of the leased area shall relieve the Lessee or its surety from any liability for breach of any obligation of this lease, including the obligation to make payment of all accrued rentals and royalties and to place all wells in the leased lands to be relinquished in condition for suspension or abandonment, and to protect or restore substantially the surface or subsurface resources in a manner satisfactory to the Lessor.

Sec. 24. REMOVAL OF PROPERTY ON TERMINATION OR EXPIRATION OF LEASE

(a) Upon the termination or expiration of this lease in whole or in part, or the relinquishment of the lease in whole or in part, as herein provided, the Lessee shall within a period of ninety (90) days (or such longer period as the Supervisor may authorize because of adverse climatic conditions) thereafter remove from the leased lands, no longer subject to the lease all structures, machinery, equipment, tools, and materials in accordance with applicable regulations and orders of the Supervisor. However, the Lessee shall, for a period of not more than six (6) months, continue to maintain any such property needed in the relinquished area, as determined by the Supervisor, for producing wells or for drilling or producing geothermal resources on other leases.

(b) Any structures, machinery, equipment, tools, appliances, and materials, subject to removal by the Lessee, as provided above, which are allowed to remain on the leased lands shall become the property of the Lessor on expiration of the 90-day period or any extension of that period which may be granted by the Supervisor. If the Supervisor directs the Lessee to remove such property, the Lessee shall do so at its own expense, or if it fails to do so within a reasonable period, the Lessor may do so at the Lessee's expense.

Sec. 25. REMEDIES IN CASE OF DEFAULT

(a) Whenever the Lessee fails to comply with any of the provisions of the Act, or the terms and stipulations of this lease, or of the regulations issued under the Act, or of any order issued pursuant to those regulations, and that default shall continue for a period of thirty (30) days after service of notice by the Lessor, the Lessor may (1) suspend operations until the requested action is taken to correct the noncompliance, or (2) cancel the lease in accordance with Sec. 12 of the Act (30 U.S.C. 1011). However, the 30-day notice provision applicable to this lease under Sec. 12 of the Act shall also apply as a prerequisite to the institution of any legal proceedings by the Lessor to cancel this lease while it is in a producing status. Nothing in this subsection shall be construed to apply to, or require any notice with respect to any legal action instituted by the Lessor other than an action to cancel the lease pursuant to Sec. 12 of the Act.

(b) Whenever the Lessee fails to comply with any of the provisions of the Act, or of this lease, or the regulations, or of any GRO Orders, or other orders, and immediate action is required, the Lessor without waiting for action by the Lessee may enter on the leased lands and take such measures as it may deem necessary to correct the failure, including a suspension of operations or production, all at the expense of the Lessee.

(c) A waiver of any particular violation of the provisions of the Act, or of this lease, or of any regulations promulgated by the Secretary under the Act, shall not prevent the cancellation of this lease or the exercise of any other remedy or remedies under paragraphs (a) and (b) of this section by reason of any other such violation, or for the same violation occuring at any other time.

(d) Nothing herein shall limit or affect the Lessee's right to a hearing and appeal as provided in Sec. 12 of the

Act and in the regulations promulgated thereunder.

(c) Upon cancellation, the Lessee shall remove all property in accordance with Sec. 24 hereof, and shall restore the leased lands in a manner acceptable to the Lessor or as may be otherwise required by the Lessor.

Sec. 26. HEIRS AND SUCCESSORS IN INTEREST – Each obligation hereunder shall extend to and be binding upon, and every benefit hereof shall inure to, the heirs, executors, administrators, successors, or assigns, of the respective parties hereto.

Sec. 27. UNLAWFUL INTEREST – No Member of, or Delegate to Congress, or Resident Commissioner, after his election or appointment, either before or after he has qualified, and during his continuance in office, and no officer, agent, or employee of the Department shall be admitted to any share or part in this lease or derive any benefit that may arise therefrom; and the provisions of Sec. 3741 of the Revised Statutes (41 U.S.C. Sec. 22), as amended, and Sections 431, 432, and 433 of Title 18 of the United States Code, relating to contracts made or entered into, or accepted by or on behalf of the United States, form a part of this lease so far as the same may be applicable.

Sec. 28. MONOPOLY AND FAIR PRICES – The Lessor reserves full power and authority to protect the public interest by promulgating and enforcing all orders necessary to insure the sale of the production from the leased lands at reasonable prices, to prevent monopoly, and to safeguard the public interest.

Sec. 29. EQUAL OPPORTUNITY CLAUSE – The Lessee agrees that, during the performance of this contract:

(1) The Lessee will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin. The Lessee will take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, color, religion, sex, or national origin. Such action shall include, but not be limited to the following: employment, upgrading, demotion, or transfer; recruitment or recruitment advertising, layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The Lessee agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided by the Lessor setting forth the provisions of this Equal Opportunity clause.

(2) The Lessee will, in all solicitations or advertisements for employees placed by or on behalf of the Lessee, state that all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, or national origin.

(3) The Lessee will send to each labor union or representative of workers with which Lessee has a collective bargaining agreement or other contract or understanding, a notice, to be provided by the Lessor, advising the labor union or workers' representative of the Lessee's commitments under this Equal Opportunity clause, and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

(4) The Lessee will comply with all provisions of Executive Order No. 11246 of September 24, 1965, as amended, and of the rules, regulations, and relevant orders of the Secretary of Labor.

(5) The Lessee will furnish all information and reports required by Executive Order No. 11246 of September 24, 1965, as amended, and by the rules, regulations, and orders of the Secretary of Labor, or pursuant thereto, and will permit access to its books, records, and accounts by the Secretary of the Interior and the Secretary of Labor for purposes of investigation to ascertain compliance with such rules, regulations, and orders.

(6) In the event of the Lessee's noncompliance with the Equal Opportunity clause of this lease or with any of said rules, regulations, or orders, this lease may be canceled, terminated or suspended in whole or in part and the Lessee may be declared ineligible for further Federal Government contracts or leases in accordance with procedures authorized in Executive Order No. 11246 of September 24, 1965, as amended, and such other sanctions as may be imposed and remedies invoked as provided in Executive Order No. 11246 of September 24, 1965, as amended, or by rule, regulation, or order of the Secretary of Labor, or as otherwise provided by law.

(7) The Lessee will include the provisions of Paragraphs (1) through (7) of this Section (29) in every contract, subcontract or purchase order unless exempted by rules, regulations, or orders of the Secretary of Labor issued pursuant to Section 204 of Executive Order No. 11246 of September 24, 1965, as amended, so that such provisions will be binding upon each contractor, subcontractor, or subcontract, or purchase order as the Secretary may direct as a means of enforcing such provisions including sanctions for noncompliance; *provided, however,* that in the event the Lessee becomes involved in, or is threatened with, litigation with a contractor, subcontractor, or vendor as a result of such direction by the Secretary, the Lessee may request the Lessor to enter into such litigation to protect the interests of the Lessor.

Sec. 30. CERTIFICATION OF NONSEGREGATED FACILITIES – By entering into this lease, the Lessee certifies that it does not and will not maintain or provide for its employees any segregated facilities at any of its establishments, and that it does not and will not permit its employees to perform their services at any location, under its control, where segregated facilities are maintained. The Lessee agrees that a breach of this certification is a violation of the Equal Opportunity clause of this lease. As used in this certification, the term "segregated facilities" means, but is not limited to, any waiting rooms, work areas, rest rooms and wash rooms, or restaurants or other eating areas, time clocks, or locker rooms, and other storage or dressing rooms, parking lots, drinking fountains, recreation or entertainment areas, transportation, and housing facilities provided for employees which are segregated by explicit directive, or are in fact segregated on the basis of race, color, religion, or national origin because of habit, local custom, or otherwise. Lessee further agrees that (except where it has obtained identical certifications from proposed contractors and subcontractors for specific time periods) it will obtain identical certifications from proposed contractors and subcontractors prior to the award of contracts or subcontracts exceeding $10,000 which are not exempt from the provisions of the Equal Opportunity clause; that it will retain such certifications in its files; and that it will forward the following certification to such proposed contractors and subcontractors (except where the proposed contractor or subcontractor has submitted identical certifications for specific time periods); it will notify prospective contractors and subcontractors of requirement for certification of nonsegregated facilities. A Certification of Nonsegregated Facilities, as required by the May 9, 1967 Order (32 F.R. 7439, May 19, 1967) on Elimination of Segregated Facilities, by the Secretary of Labor, must be submitted prior to the award of a contract or subcontract exceeding $10,000 which is not exempt from the provisions of the Equal Opportunity clause. The certification may be submitted either for each contract and subcontract or for all contracts and subcontracts during a period (i.e., quarterly, semiannually, or annually).

Sec. 31. SPECIAL STIPULATIONS – *(stipulations, if any, are attached hereto and made a part hereof)*

In witness whereof the parties have executed this lease.
Lessee:

THE UNITED STATES OF AMERICA, Lessor:

(Signature of Lessee)

By ____________________
(Authorized Officer)

(Signature of Lessee)

(Title)

[SEAL]

(Date)

(Date)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION

GEOTHERMAL RESOURCES OPERATIONAL ORDER NO. 1

Effective February 1, 1975

EXPLORATORY OPERATIONS

This Order is established pursuant to the authority prescribed in 30 CFR 270.11 and in accordance with 30 CFR 270.78. All exploratory operations other than drilling of exploratory and development wells will be conducted in accordance with the provisions of this Order. All plans for exploratory operations to be conducted shall include provisions for appropriate environmental protection and reclamation of disturbed lands. A cultural resources investigation approved by the Area Geothermal Supervisor (Supervisor) shall be performed prior to any surface disturbance other than Casual Use.

All variances from the requirements specified in this Order shall be subject to approval pursuant to 30 CFR 270.48. Each Notice of Intent to Conduct Geothermal Resources Exploration Operations shall include a notation of any proposed variances from the requirements of this Order. References in this Order to approvals, determinations, or requirements are to those given or made by the Supervisor or his delegated representative.

The following exploratory operations and reasonable expenditures therefor will qualify as diligent exploration if approved by the Supervisor prior to the initiation of such operations.

1. Casual Use. Casual Use shall include any entrance on the leased lands for geological reconnaissance or surveying purposes. Sampling of springs and water wells on the lease for geochemical analysis shall be construed as casual use. Such non-disturbing surveys and reconnaissance operations will not require a Notice of Intent to Conduct Geothermal Resources Exploration Operations. The lessee shall notify the Supervisor prior to commencing such casual use operations. Casual Use operations proposed or completed shall be included in any subsequent Plan of Operations.

2. Geophysical Exploration. Geophysical exploration shall include, but is not limited to, surface electrical resistivity surveys, seismic ground noise surveys, passive micro-earthquake monitoring surveys, magneto-telluric surveys and all other geophysical surveys, including airborne techniques.

Geophysical surveys other than airborne techniques will require a Notice of Intent to Conduct Geothermal Resources Exploration Operations, (Form 3200-9). All such anticipated surveys should be included in the Plan of Operations and must be approved by the Supervisor before the work is begun.

The lessee shall furnish the Supervisor two copies of the records of such surveys within 30 days after the completion of such operations.

3. Drilling of Shallow Holes. Drilling of shallow holes for the measurement of temperature gradients or heat flow will be considered as an exploration operation and will require approval of a Notice of Intent to Conduct Geothermal Resources Exploration Operations (Form 3200-9) by the Supervisor. The following stipulations shall apply to the drilling of such shallow holes:

A. Holes for measuring temperature gradients shall be limited to a depth of 152 metres (500 feet), unless otherwise authorized by the Supervisor.

B. Return-line temperatures shall be taken at no less than 9-metre (30 foot) intervals during drilling operations on shallow holes drilled with mud. If return-line mud temperature should reach 52°C. (125°F.), drilling ahead shall cease immediately and the hole will be either

(1) Completed as an observation hole by running steel tubing as deep as possible, filling the annulus with drilling mud from total depth to 3 metres (10 feet) below the surface and with cement from 3 metres (10 feet) to the surface;

(2) Abandoned by filling the hole with drilling mud from total depth to 3 metres (10 feet) below the surface and cement to the surface thereafter, or

(3) Equipped with mud cooling and wellhead control devices to maintain well control and mud returns temperature at or below 52°C. (125°F.).

C. If flowing steam or hot water at 65°C (150°F.) or greater is encountered, further drilling shall stop immediately and the hole will be either

(1) Completed as an observation hole using steel tubing cemented from total depth to surface; or

(2) Abandoned by plugging with cement from total depth to surface.

D. If cold flowing artesian water is encountered, the hole will be completed as in (C) hereinabove, except that plastic tubing may be used.

If the conditions outlined in (B), (C) or (D) are encountered, the Supervisor shall be notified immediately.

No exceptions to the stipulations of (B), (C) or (D) will be allowed without specific prior permission of the Supervisor.

E. The lessee shall submit the following information with the Notice of Intent to Conduct Geothermal Resources Exploration Operations (Form 3200-9):

(1) The approximate location (to the nearest 30 metres (100 feet) from some identifiable marker or object within the smallest legal subdivision) and hole number or designation of each proposed hole and probable order of drilling;

(2) The type and size of drilling rig;

(3) The proposed drilling program including the drilling system (type of bit and circulating medium), approximate depths and casing (conductor) program for each such hole;

(4) The type of drilling sump and proposed method of sump abandonment at each location;

(5) The approximate time that each hole will be used for observation; and

(6) The proposed method of abandonment for each hole. Additionally, the lessee shall notify and receive the approval of the Supervisor prior to any change in the location of an approved hole or for any additional holes which the lessee desires to drill.

F. Locations proposed in natural thermal areas within a 300-metre (1,000-foot) radius of hot springs, fumaroles, or other surface geothermal indicia, or in areas of known artesian water flow, will require a detailed drilling program for each hole, approved by the Supervisor. The Supervisor may require special drilling and completion techniques for such holes (such as cemented surface casing and simple expansion-type blowout preventers) to safely control formations containing geothermal or other resources which may be penetrated.

G. A supply of mud and lost circulation material shall be kept on hand while drilling to control abnormal pressure if rotary equipment is used.

H. Holes shall be completed for observation purposes in a manner which will allow satisfactory subsequent abandonment. As a minimum, the annular space shall be filled with mud (cuttings and dirt if drilled with air or auger) to 3 metres (10 feet) below the surface and with cement from 3 metres (10 feet) to the surface, and the tubing shall be capped when not in use.

I. Holes shall be abandoned in a manner that will prevent subsurface interzonal migration of fluids and surface leakage. As a minimum, the top 3 metres (10 feet) of tubing below the surface shall be filled with cement. Tubing shall be cut off at ground level or as directed by the Supervisor.

4. Reporting Completion of Exploration Operations. The Notice of Completion of Geothermal Resources Exploration Operations (Form 3200-10) shall be submitted in triplicate, and shall include the following information for each hole drilled:

A. Final hole designation and location;

B. A driller's log noting water table and water aquifers encountered (if determined), and salt, coal beds or other mineral deposits, if present;

C. Method of completion, cementing, and casting and/or tubing used;

D. Complete details of the abandonment procedures;

E. Any information on drilling difficulties or unusual circumstances encountered which would be helpful in assuring future safety of operations or protection of the environment in the area concerned; and

F. Temperature data and logs for each hole surveyed.

5. General. Drilling fluids or cuttings shall not be discharged onto the surface where such discharge might contaminate lakes and perennial or intermittent streams. Excavated pits or sumps used in drilling shall be backfilled as soon as drilling is completed and restored to conform with the original topography. Unattended sumps shall be completely fenced for the protection of the public, domestic animals and wildlife.

6. Notice of Entry. Applicant shall contact the appropriate U. S. Geological Survey Geothermal District Office prior to entry on the land to conduct exploration operations.

Reid T. Stone

Reid T. Stone
Area Geothermal Supervisor

Approved:

Russell G. Wayland

Russell G. Wayland,
Chief, Conservation Division

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION

GEOTHERMAL RESOURCES OPERATIONAL ORDER NO. 2

Effective February 1, 1975

DRILLING, COMPLETION AND SPACING OF GEOTHERMAL WELLS

This Order is established pursuant to the authority prescribed in 30 CFR 270.11 and in accordance with 30 CFR 270.14, 270.15, and 270.40. All wells shall be drilled in such a manner as to minimize damage to the environment and to protect life, health, property, usable ground waters and geothermal resources.

All exploratory wells drilled for geothermal resources shall be drilled in accordance with the provisions of this Order. Initial development wells drilled for geothermal resources shall be drilled in accordance with the provisions of this Order, and these provisions shall continue in effect until field rules are issued. After field rules have been established by the Area Geothermal Supervisor (Supervisor), development wells in the individual fields shall be drilled in accordance with such rules.

Where sufficient geologic and engineering information is obtained through exploratory drilling, lessees may make application or the Supervisor may request the lessee to submit an application for the establishment of field rules. The Supervisor may issue field rules at any time he deems appropriate upon failure of the lessee to timely file for such field rules.

All wells drilled under the provisions of this Order shall have been included in an exploratory or development Plan of Operations as required under 30 CFR 270.34. Each Application for Permit to Drill (Form 9-331C) shall include all information required under 30 CFR 270.71, and shall include a notation of any proposed variances from the requirements of this Order. All variances from the requirements specified in this Order shall be subject to approval pursuant to 30 CFR 270.48. References in this Order to approvals, determinations, and requirements for submitting of information or applications for approval are to those granted, made or required by the Supervisor or his delegated representative. The lessee shall comply with the following requirements:

1. Well Casing. All wells shall be cased and cemented in accordance with the requirements of 30 CFR 270.15, and the application for permit to drill shall include the casing design safety factors for collapse, tension and burst. The permanent wellhead completion equipment shall be attached to the production casing or to the intermediate casing if the production casing does not reach to the surface except as otherwise authorized by the Supervisor to meet special well conditions. All casing strings reaching the surface shall be cemented at a sufficient

depth to provide adequate anchorage and support for the casing and any blowout prevention equipment required thereon. For the purpose of this Order, the several casing strings in order of normal installation are (1) conductor, (2) surface, (3) intermediate and (4) production strings. The following casing setting depth requirements are general in nature and subject to variations to permit the casing to be set and cemented in a competent formation. The Supervisor's determination of adequate casing setting depths shall be based upon all geologic and engineering factors including apparent geothermal gradients, depths and pressures of the various formations to be penetrated and all other pertinent information about the area. All depths in this Order refer to true vertical depth (TVD) below ground level, unless otherwise specified.

A. Conductor Casing. This casing shall be set at a minimum depth of 15 metres (50 feet) and a maximum depth of 60 metres (200 feet) before drilling into shallow formations suspected or known to contain geothermal resources, non-condensible gases, or other mineral resources or upon encountering such formations.

B. Surface Casing. This casing shall be set at a depth equivalent to or in excess of ten percent of the proposed total depth of the well provided, however, that such setting depth shall be not less than 60 metres (200 feet) nor more than 400 metres (1,300 feet).

C. Intermediate Casing. This casing shall be set at any time when required by well conditions encountered in drilling below the surface casing such as anomalous pressure zones, uncased fresh water aquifers, cave-ins, washouts, lost circulation zones, rapidly increasing thermal gradients or other drilling hazards. If a liner is used as an intermediate string, the lap shall be tested by a fluid entry or pressure test to determine whether a seal between the liner top and the next larger casing string has been achieved. The liner overlap shall be a minimum of 30 metres (100 feet). The test shall be recorded on the driller's log and may be witnessed by the Supervisor. In the event of lap or casing failure during the test, the lap or casing must be repaired or recemented and successfully retested as required by the Supervisor.

D. Production Casing. This casing may be set at the top of or through the potential producing zone and shall be set before completing the well for production. Production casing shall be run to the surface or lapped into the next larger casing string. The liner overlap, if utilized, shall be at least 30 metres (100 feet) and shall be tested, witnessed and recorded as in the case of intermediate casing hereinabove. In the event of lap or casing failure during the test, the lap or casing must be repaired or recemented and successfully retested as required by the Supervisor. Production casing shall normally be of consistent nominal outside diameter from the surface or from the top of the lap to the casing shoe. The surface casing shall not be used as production casing, unless otherwise authorized by the Supervisor to meet special well conditions.

E. Cementing of Casing. The conductor and surface casing strings shall be cemented with a quantity of cement sufficient to fill the annular space back to the surface. The intermediate casing string shall likewise be cemented back to the surface or to the top of the lap if a liner is used as an intermediate string. Production casing shall be cemented with a high temperature resistant admix, unless waived by the Supervisor and shall be cemented in a manner necessary to exclude, isolate or segregate overlying formation fluids from the geothermal resources zone and to prevent the movement of fluids into possible fresh water zones. Production casing shall be cemented back to the surface or, if lapped, to the top of the lap. A temperature or cement bond log may be required by the Supervisor after setting and cementing the production casing and after all primary cementing operations if an unsatisfactory cementing job is indicated. Proposed well cementing techniques differing from the requirements of this paragraph will be considered by the Supervisor on an individual well basis.

F. Pressure Testing. Prior to drilling out the casing shoe after cementing, all casing strings set to a depth of 152 metres (500 feet) or greater, except for conductor casing, shall be pressure tested to a minimum pressure of 69 bars (1,000 psi) or 0.045 bars/metre (0.2 psi/ft) whichever is greater. All casing strings set at a depth less than 152 metres (500 feet), except for conductor casing, shall be pressure tested to a minimum pressure of 35 bars (500 psi). Such test shall not exceed the rated working pressure of the casing or the blowout preventer stack assembly, whichever is lesser.

In the event of casing failure during the test, the casing must be repaired or recemented until a satisfactory test is obtained. A pressure decline of 10 percent or less in 30 minutes shall be considered satisfactory.

Casing test results shall be recorded on the driller's log and reported to the Supervisor within 30 days after the completion of such test. Advance notice of all casing and lap tests shall be given in sufficient time to enable the Supervisor to be present to witness such tests. The casing and lap test reports shall give a detailed description of the test, including mud and cement volumes, lapse of time between running and cementing casing and testing, method of testing and test results.

G. Directional Surveys.

(1) General. Deviation surveys (inclination from vertical or single shot) shall be taken on all wells during the normal course of drilling at intervals not to exceed 152 metres (500 feet). The Supervisor may require a directional survey giving both inclination and azimuth or a dipmeter to be obtained on all wells. In calculating all surveys, a correction from true north to Lambert-Grid north shall be made after making the magnetic to true north correction. All surveys shall be filed with the Supervisor. Where directional surveys are required, composite surveys shall be filed with the Supervisor showing the interval from the bottom of the conductor casing to total depth.

(2) Vertical Wells. Wells are considered vertical if inclination does not exceed an average of five degrees from the vertical. The Supervisor may require a directional survey giving both inclination and azimuth at intervals not exceeding 30 metres (100 feet) between stations prior to, or upon, setting any casing string or liner (except conductor casing) and at total depth on any vertical well drilled in close proximity to lease boundaries or areas with an unstable land surface, highly faulted or steeply dipping beds, or in areas of suspected abnormal formation pressures.

(3) Directional Wells. Wells are considered directional if inclination exceeds an average of five degrees from the vertical. Directional surveys giving both inclination and azimuth shall be obtained at intervals not to exceed 30 metres (100 feet) between stations prior to, or upon, setting any casing string or liner (except conductor casing) and at total depth.

2. Blowout Prevention Equipment and Procedures. All necessary precautions shall be taken to keep all wells under control at all times, utilize trained and competent personnel, and utilize properly maintained equipment and materials. Blowout preventers and related well control equipment shall be installed, tested immediately thereafter and maintained ready for use until drilling operations are completed. Certain components, such as packing elements and ram rubbers, shall be of high temperature resistant material as necessary. All kill lines, blowdown lines, manifolds and fittings shall be steel and shall have a temperature derated minimum working pressure rating equivalent to the maximum anticipated wellhead surface pressure. Subject to subparagraphs (A) and (B) hereinbelow blowout prevention equipment shall have manually operated gates and hydraulic actuating systems and accumulators of sufficient capacity to close all of the hydraulically-operated equipment and have a minimum pressure of 69 bars (1,000 psi) remaining on the accumulator. Dual control stations shall be installed with a high

pressure backup system. One control panel shall be located at the driller's station and one control panel shall be located on the ground at least 15 metres (50 feet) away from the wellhead or rotary table. Air or other gaseous fluid drilling systems shall have blowout prevention assemblies. Such assemblies may include, but are not limited to, a rotating head, a double ram blowout preventer or equivalent, a banjo-box or an approved substitute therefor and a blind ram blowout preventer or gate valve, respectively. Exceptions to the requirements of this paragraph will be considered by the Supervisor only for certain geologic and well conditions such as stable surface areas with known low subsurface formation pressures and temperatures.

A proposed blowout prevention program and a blowout contingency plan including proposed containment, public health and safety and clean-up measures shall be submitted with the Application for Permit to Drill (Form 9-331C).

A. Conductor Casing. Before drilling below this string, at least one remotely controlled hydraulically-operated expansion type preventer or an acceptable alternative, approved by the Supervisor, including a drilling spool with side outlets or equivalent, shall be installed. A kill line and blowdown line with appropriate fittings shall be connected to the drilling spool.

B. Surface, Intermediate and Production Casing. Before drilling below any of these strings, the blowout prevention equipment shall include a minimum of:

(1) One expansion-type preventer and accumulator or a rotating head;

(2) A manual and remotely controlled hydraulically-operated double ram blowout preventer or equivalent having a temperature derated minimum working pressure rating which exceeds the maximum anticipated surface pressure at the anticipated reservoir fluid temperature;

(3) A drilling spool with side outlets or equivalent;

(4) A fillup line;

(5) A kill line equipped with at least one valve; and

(6) A blowdown line equipped with at least two valves and securely anchored at all bends and at the end.

C. Testing and Maintenance. Ram-type blowout preventers and auxiliary equipment shall be tested to a minimum of 69 bars (1,000 psi) or to the working pressure of the casing or assembly, whichever is the lesser. Expansion-type blowout preventers shall be tested to 70 percent of the above pressure testing requirements.

The blowout prevention equipment shall be pressure tested:

(1) When installed;

(2) Prior to drilling out plugs and/or casing shoes;

(3) Not less than once each week, alternating the control stations; and

(4) Following repairs that require disconnecting a pressure seal in the assembly.

During drilling operations blowout prevention equipment shall be actuated to test proper functioning as follows:

(1) Once each trip for blind and pipe rams but not less than once each day for pipe rams; and

(2) At least once each week on the drill pipe for expansion-type preventers.

All flange bolts shall be inspected at least weekly and re-tightened as necessary during drilling operations. The auxiliary control systems shall be inspected daily to check the mechanical condition and effectiveness and to ensure personnel acquaintance with the method of operation. Blowout prevention and auxiliary control equipment shall be cleaned, inspected and repaired, if necessary, prior to installation to assure proper functioning. Blowout prevention controls shall be plainly labeled, and all crew members shall be instructed on the function and operation of such equipment. A blowout prevention drill shall be conducted weekly for each drilling crew. All blowout prevention tests and crew drills shall be recorded on the driller's log.

D. Related Well Control Equipment. A full opening drill string safety valve in the open position shall be maintained on the rig floor at all times while drilling operations are being conducted. A kelly cock shall be installed between the kelly and the swivel.

3. Drilling Fluid. The properties, use and testing of drilling fluids and the conduct of related drilling procedures shall be such as are necessary to prevent the blowout of any well. Sufficient drilling fluid materials to ensure well control shall be maintained in the field area readily accessible for use at all times.

A. Drilling Fluid Control. Before pulling drill pipe, the drilling fluid shall be properly conditioned or displaced. The hole shall be kept reasonably full at all times, however, in no event shall the annular mud level be deeper than 30 metres (100 feet) from the rotary table when coming out of the hole with drill pipe. Mud cooling techniques shall be utilized when necessary to maintain mud characteristics for proper well control and hole conditioning.

B. Drilling Fluid Testing. Mud testing and treatment consistent with good operating practice shall be performed daily or more frequently as conditions warrant. Mud testing equipment shall be maintained on the drilling rig at all times.

The following drilling fluid system monitoring or recording devices shall be installed and operated continuously during drilling operations, with mud, occurring below the shoe of the conductor casing. No exceptions to these requirements will be allowed without the specific prior permission of the Supervisor:

(1) High-low level mud pit indicator including a visual and audio-warning device;

(2) Degassers, desilters and desanders;

(3) A mechanical, electrical or manual surface drilling fluid temperature monitoring device. The temperature of the drilling fluid going into and coming out of the hole shall be monitored, read and recorded on the driller's or mud log for a minimum of every 9 metres (30 feet) of hole drilled below the conductor casing; and

(4) A hydrogen sulfide indicator and alarm shall be installed in areas suspected or known to contain hydrogen sulfide gas which may reach levels considered to be dangerous to the health and safety of personnel in the area.

C. Monitoring. From the time drilling operations are initiated and until the well is completed or abandoned, a member of the drilling crew or the toolpusher shall monitor the rig floor at all times for surveillance purposes, unless the well is secured with blowout preventers or cement plugs.

4. Well Logging. All wells shall be logged with an induction electric log or equivalent from total depth to the shoe of the conductor casing. The Supervisor may grant an exception to this requirement when well conditions make it impractical or impossible to meet the above requirements.

A. Electric Logs. The lessee shall furnish to the Supervisor two legible exact copies of all logs run, within 30 days after completion of drilling operations on each well. Two copies of field prints of such logs shall be made immediately available to the Supervisor upon his request. Two copies of chemical analyses of geothermal fluids or other similar services performed shall be submitted to the Supervisor within 30 days after such services are completed.

B. Lithologic Logs. Two legible exact copies of core analysis reports and lithologic (mud) logs shall be submitted to the Supervisor within 30 days after the completion of such reports or logs, when such services are used. However, daily logs shall be made available to the Supervisor immediately upon the completion of such daily logs upon his request.

5. Wellhead Equipment and Testing.

A. Completions. All wellhead connections shall be fluid pressure tested to the API or ASA working pressure rating. Cold water is recommended as the testing fluid. Welding of wellhead connections shall be performed by a certified welder using materials in conformance with ASTM specifications.

B. Wellhead Equipment. All completed wells shall be equipped with a minimum of one casinghead with side outlets, one master valve and one production valve, unless otherwise authorized by the Supervisor. All casingheads, Christmas trees, fittings and connections shall have a temperature derated working pressure equal to or greater than the surface shut-in pressure of the well at reservoir temperature. Packing, sealing mediums and lubricants shall consist of materials or substances that function effectively at, and are resistant to, high temperatures. Wellhead equipment, valves, flanges and fittings shall meet minimum ASA standards or minimum API Standard 6A specifications. Casinghead connections shall be made such that fluid can be pumped between casing strings.

C. Testing. Any well showing sustained casinghead pressure or leaking of geothermal fluids between casing strings shall be tested to determine the origin of the failure, when such failure point is not otherwise determinable, and corrective measures shall be taken.

6. Well Spacing. No producing interval of any well shall be located within 30 metres (100 feet) of the outer boundaries of the leased lands, except where approved by the Supervisor. No surface location of a well shall be located within 15 metres (50 feet) of the boundary of any legal subdivision unless otherwise authorized by the Supervisor. The Supervisor may approve or prescribe such well

spacing as he determines to be necessary for the proper development of the geothermal resources in accordance with the provisions of 30 CFR 270.15.

Reid T. Stone
Reid T. Stone
Area Geothermal Supervisor

Approved:

Russell G. Wayland
Russell G. Wayland
Chief, Conservation Division

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION

GEOTHERMAL RESOURCES OPERATIONAL ORDER NO. 3

Effective February 1, 1975

PLUGGING AND ABANDONMENT OF WELLS

This Order is established pursuant to the authority prescribed in 30 CFR 270.11 and in accordance with 30 CFR 270.14 and 270.45. The lessee shall comply with the following minimum plugging and abandonment procedures for all geothermal resources wells. Oral approvals shall be in accordance with 30 CFR 270.11. All variances from the requirements specified in this Order shall be subject to approval pursuant to 30 CFR 270.48. Each Sundry Notice (Form 9-331) shall include a notation of any proposed variances from the requirements of this Order. References in this Order to approvals, determinations or requirements are to those given or made by the Area Geothermal Supervisor (Supervisor) or his delegated representative.

The lessee shall promptly plug and abandon any well on the leased land that is not in use or demonstrated to be potentially useful. No well shall be abandoned until its lack of capacity for further profitable production of geothermal resources has been demonstrated to the satisfaction of the Supervisor. No well shall be plugged and abandoned until the manner and method of plugging have been approved or prescribed by the Supervisor.

Cement used to plug any geothermal resources well, except that cement or concrete used for surface plugging, shall be placed in the hole by pumping through drill pipe or tubing. Such cement shall consist of a high temperature resistant admix, unless this requirement is waived by the Supervisor in accordance with the particular circumstances existing in that well or area.

Prior to commencing abandonment operations, the Supervisor shall be notified of all such proposed operations.

Each Sundry Notice (Form 9-331) shall include all information required under 30 CFR 270.45 and 270.72. Any bond or rider thereto covering a lease or an individual well thereon, shall remain in full force and effect until the lease or individual well is properly abandoned and the surface properly restored. Written approval of the abandonment must be obtained from the Supervisor before release of any bonds will be recommended.

1. Permanent Abandonment.

A. Uncased Hole. In uncased portions of wells, cement plugs shall be placed to protect all subsurface mineral resources including fresh water aquifers. Such plugs shall extend a minimum of 30 metres

(100 feet) below, if possible, and 30 metres (100 feet) above such aforementioned zones. Cement plugs shall be placed in a manner necessary to isolate formations and to protect the fluids in such formations from interzonal migration or contamination.

B. Open Hole. Where there is open hole (uncased and open into the casing string above), a cement plug shall be placed in the deepest casing string by either (1) or (2) below. In the event lost circulation conditions exist or are anticipated, or if the well has been drilled with air or other gaseous substance, the plug shall be placed in accordance with (3) below.

(1) A cement plug shall be placed across the shoe extending a minimum of 30 metres (100 feet) above and 30 metres (100 feet) below; or

(2) A cement retainer with effective back pressure control set approximately 30 metres (100 feet) above the casing shoe with at least 61 metres (200 feet) of cement below the retainer and 30 metres (100 feet) of cement above.

(3) A permanent bridge plug set at the casing shoe and capped with a minimum of 61 metres (200 feet) of cement.

C. Perforations, Junk, Fish and Collapsed Pipe. A cement plug shall be placed across production perforations, extending 30 metres (100 feet) below (where possible) and 30 metres (100 feet) above the perforated interval. When a cement retainer is used to squeeze cement the perforated interval, the retainer shall be set a minimum of 30 metres (100 feet) above the perforations. Where the casing contains perforations at or below fish, junk or collapsed casing, thereby perventing cleanout operations, a cement retainer shall be set at least 30 metres (100 feet) above such point, and the interval below the retainer shall be squeeze cemented.

D. Casing Shoes, Stubs, Laps, and Liners. No casing shall be cut and recovered without first obtaining the written approval of the Supervisor. A cement plug shall be placed across all casing stubs, laps, liner tops and all casing shoes not protected by an inner casing string. Such plug shall extend a minimum of 15 metres (50 feet) below and 15 metres (50 feet) above any such shoe, stub, lap or liner top.

E. Plugging of Annular Space. All open annuli extending to the surface shall be plugged with cement.

F. Surface Plug. The innermost casing string which reaches ground level shall be cemented or concreted to a minimum depth of 15 metres (50 feet)measured from 2 metres (6 feet) below ground level.

G. Testing of Plugs. The hardness and location of cement plugs placed across perforated intervals and at the top of uncased or open hole shall be verified by setting down with tubing or drill pipe a minimum of 6,803 kilograms (15,000 pounds) weight on the plug or the maximum weight of the available tubing or drill pipe string, if less than 6,803 kilograms (15,000 pounds).

H. Mud. The intervals of the hole not filled with cement shall be filled with good quality heavy mud.

1. Surface Restoration. All casing strings shall be cut off at least 2 metres (6 feet) below ground level and capped by welding a steel plate on the casing stub. Cellars, pads, structures and other facilities shall be removed. The surface area shall be restored as specified by the Supervisor in consultation with the appropriate surface management agency.

2. Temporary Abandonment. An uncompleted drilling well that is to be temporarily abandoned shall be mudded and cemented as required hereinabove for permanent abandonment except for the provisions of subparagraphs E, F, and I.

3. Suspended Wells. The drilling equipment shall not be removed on any geothermal resources well where drilling operations have been suspended, either temporarily or indefinitely, without prior approval of the Supervisor and after approved measures have been taken to close the well and to protect all subsurface resources, including fresh water aquifers.

Reid T Stone
Reid T. Stone
Area Geothermal Supervisor

Approved:

Russell G. Wayland
Russell G. Wayland,
Chief, Conservation Division

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION

GEOTHERMAL RESOURCES OPERATIONAL ORDER NO. 4

Effective______________

GENERAL ENVIRONMENTAL PROTECTION REQUIREMENTS

This Order is established pursuant to the authority prescribed in 30 CFR 207.11 and in accordance with 30 CFR 270.2, 270.34(k), 270.37, 270.41, 270.42, 270.43, 270.44, and 270.76. Lessees shall comply with the provisions of the Order. All variances from the requirements specified in this Order shall be subject to approval pursuant to 30 CFR 270.48. Reference in this Order to approvals, determinations or requirments are to those given or made by the Area Geothermal Supervisor (Supervisor) or his delegated representative.

All data submitted under this Order shall be available for inspection in accordance with the Freedom and Information Act of 1966 (PL 89-487), or as amended in 1974 (PL 93-502), except information such as geological, geophysical, reservoir, and production data and interpretations of such data, maps and related files for which proprietary status is requested by the lessee and subsequently approved by the Supervisor.

Protection of the environment includes the lessee's responsibility to: conduct exploration and development operations in a manner that provides maximum protection of the environemnt; rehabilitate disturbed lands; take all necessary precautions to protect the public health and safety; and conduct operations in accordance with the spirit and objectives of all applicable Federal environmental legislation and supporting Executive Orders.

Adverse environmental impacts from geothermal-related activity shall be prevented or mitigated through enforcement of applicable Federal, State and local standards, and the application of existing technology. Inability to meet these environmental standards or continued violation of environmental standards due to operations of the lessee, after notification, may be construed as grounds for the Supervisor to order a suspension of operations.

The lessee shall be responsible for the monitoring of readily identifieable localized environmental impacts associated with specific activities that are under the control of the lessee. Monitoring of environmental impacts may be conducted by the use of aerial surveys, inspections, periodic samplings, continuous recordings or by such other means or methods as required by the Supervisor. Due to the differing natural environmental conditions among geothermal areas, the extent and frequency of such monitoring activities will be determined by the Supervisor on an individual basis. In the event the Supervisor determines that the degree and adequacy of existing environmental protection regulations in certain areas are insufficient, the Supervisor may establish additional and more stringent requirements by the establishment of field orders or by modifying existing orders.

Lessees shall provide for acquisition of environmental baseline data as required in accordance with 30 CFR 270.34(k) for a period of one year prior to submission of a plan for production. Techniques and standards to be used by the lessee for meeting these requirements shall receive prior approval by the Supervisor. The lessee, in accordance with the requirements of 30 CFR 270.76, shall file in duplicate with the Supervisor, on or before March 1 of each year, an annual report of compliance with environmental protection requirements for the previous calendar year.

1. Aesthetics. The lessee shall reduce visual impact where feasible by the careful selection of sites for operations and facilities on leased lands. The design and construction of facilities shall be conducted in a manner such that the facilities will blend into the natural environmental setting of the area by the appropriate use of landscaping, vegetation, compatible color schemes and minimim profiles. Native plants or other compatible vegetation shall be used, where possible, for landscaping and revegetation.

2. Land Use and Reclamation. Operating plans shall be designed so that operations will result in the least disturbance of land, water and vegetation. Existing roads shall be used where suitable. Entry upon certain environmentally fragile land areas (designated by the surface management agency) may be either seasonally restricted or restricted to special vehicles or transportation methods which will minimize disturbance to the surface or other resources, as specified by the Supervisor and surface management agency.

Operating plans shall provide for the reclamation and revegetation of all disturbed lands in a manner approved by the Supervisor and the appropriate surface management agency. Land reclamation may include preparation and seeding with prescribed wildlife food and plant cover or improved and acceptable substitutes thereof which will equal or enhance the food values for indigenous wildlife species and domesticated animals. Temporary fencing for such reclaimed areas may be required to facilitate restoration thereof.

The lessee shall at all times maintain the leased lands in a safe and orderly condition and shall perform the operations in a workmanlike manner. The lessee shall remove or store all supplies, equipment and scrap in a timely and orderly fashion.

Operations under a geothermal lease shall not unreasonably interfere with or endanger operations under any other lease, license, claim, permit or other authorized use on the same lands.

3. Public Access. The public shall have free and unrestricted access to geothermal leased lands, excepting however, where restrictions are necessary to protect public health and safety or where such public access would unduly interfere with the lessee's operations or the security thereof. The lessee shall provide warning signs, fencing, flag men, barricades or other safety measures deemed necessary by the Supervisor to protect the public, wildlife and livestock from hazardous geothermal or related activities.

4. Recreation. Recreational values shall be adequately protected through planning and designing of site development to minimize the aesthetic degradation of the particular recreation area. The lessee shall generally be restricted from surface locations for drilling and other lease opeations within 61 metres (200 feet) of established recreation sites and access routes thereto. However, the lessee may relocate the recreational site and access routes when approved by the Supervisor with the concurrence of the land management agency.

5. Slope Stability and Erosion Control. Operations shall be conducted in such a manner so as to minimize erosion and disturbance to natural drainage. The lessee shall provide adequate erosion and drainage control to prevent sediments from disturbed sites from entering water courses for soil and natural resource conservation protection.

Mitigating measures to lessen environmental damage may include reseeding of disturbed soils, chemical stabilization, and dust and erosion control on well sites, roads and construction areas.

All operating plans shall give proper consideration to the potential hazards of slope instability. Where potentially unstable ground conditions exist, design of proposed roads, drill sites and surface facilities shall be approved by and constructed under the supervision of a qualified engineer or engineering geologist satisfactory to the Supervisor.

6. Biota. The lessee shall conduct all operations in such a manner as to afford reasonable protection of fish, wildlife, and natural habitat. The lessee shall take such measures as are necessary for the conservation of endangered and threatened species of flora and fauna as set forth in

applicable Federal or state legislation, executive orders, and regulations such as the Endangered Species Act of 1973 and the Migratory Bird Act of 1966.

Federal or state agencies may advise the Supervisor when there are endangered species inhabiting or utilizing the immediate area of operations or proposed operations. When such species would be adversely affected by the lessee's operations on the leased lands, the lessee shall implement whatever measures the Supervisor finds necessary to minimize or eliminate such adverse effects and to protect the endangered species. Such measures may be in addition to provisions already set forth in the lease or accompanying stipulations.

The Supervisor may receive information from recognized experts that a delicate balance of flora and/or fauna exists in the area of operations or proposed operations. Upon receiving such notice, the supervisor will request a timely response from appropriate Federal and state agencies regarding: (1) An assessment of the status of flora and fauna in the area which may be adversely affected by operations and, (2) advice as to reasonable mitigating measures appropriate to minimizing or preventing adverse trends in populations, growth, vegetative recovery or repopulations in potentially affected flora and/or fauna. Based on timely receipt of advice from appropriate agencies, the Supervisor will direct the lessee to take appropriate mitigating measures to minimize significant adverse trends in flora and fauna. Such measures may include, but not be limited to, revegetation with grasses, shrubs or other vegetation of high forage values desirable for habitat, replacement of fauna where lost, or replacement of water supply or sources where destroyed.

Where the lessee's operations have destroyed significant flora and/or fauna or their natural habitat and replacement by natural processes will not take place in a normal growth cycle, the lessee shall take reasonable measures to replace those species or their habitat with the same or other acceptable species as directed by the Supervisor. The Supervisor's requirements shall be based on advice received from appropriate Federal and state agencies.

7. Cultural Resources Preservation. The lessee shall exercise due diligence in the conduct of his operations to protect and preserve significant archaeological, historical, cultural, paleontological and unique geologic sites. The lessee shall not disturb any known cemetary or burial ground of any group or culture.

Previously unknown sites uncovered by the lessee shall be immediately reported to the Supervisor, and operations on the particular site shall cease until said site can be assessed for its archaeological value and preservation. Necessary controls and remedial actions for the protection and preservation of cultural resources shall be issued on an individual site basis by the Supervisor as warranted.

The preservation, restoration, maintenance and nomination of all resources for purposes of the National Register of Historic Places shall be in accordance with the provisions of Executive Order 11593 (36 FR 8921) entitled, "Protection and Enhancement of the Cultural Environment," or any ammendments thereto.

8. Subsidence and Seismicity. Surveying of the land surface; prior to and during geothermal resources production will be required for determining any changes in elevation of the leased lands. Lessee shall make such resurveys as required by the Supervisor to ascertain if subsidence is occurring. Production data, pressures, reinjection rates and volumes shall be accurately recorded and filed monthly with the Supervisor as provided in 30 CFR 270.37. In the event subsidence activity results from the production of geothermal resources, as determined by surveys by the lessee or a governmental body, the lessee shall take such mitigating actions as required by the lease terms or by the Supervisor.

If subsidence is determined by the Supervisor to present a significant hazard to operations or adjoining land use, then the Supervisor may require remedial action including, but not limited to, reduced production rates, increased injection of waste or other fluids or a suspension of production.

A. Surveys. All required surveys shall be second order or better and shall be conducted under the direct supervision of a registered civil engineer or licensed land surveyor using equipment acceptable by the National Ocean Survey for second order surveys. All such work shall be coordinated with the county surveyor of the county in which the surveys and bench marks are to be established. Level lines and networks shall be tied to available regional networks.

Adjusted survey data shall be filed with the Supervisor within 60 days after leveling is completed. Any lessee having a commercially productive geothermal well or wells shall participate in cooperative county-state subsidence detection programs. All survey data filed with the Supervisor shall be available to the public.

B. Bench Marks. One or more wellsite bench marks shall be required at each completed well prior to prolonged production, and said bench marks shall be located in a manner such that there is a minimal probability of destruction or damage to said bench marks. Wellsite bench marks shall be tied to existing regional networks. Additional bench marks between the wellsites and the regional network shall be at 0.8 km (half-mile) intervals or as otherwise specified by the Supervisor. These bench marks shall be resurveyed during well production operations on a periodic basis as determined by the supervisor.

Acceptable bench marks include, but are not limited to, a brass rod driven to refusal or 9 metres (about 30 feet) and fitted with an acceptable brass plate and permanent structure with an installed acceptable brass plate.

C. Reservoir Data. Initial reservoir pressure and temperature shall be reported to the Supervisor in duplicate on Well Completion or Recompletion Report (Form 9-330C) for all completed wells within 30 days after the completion of measurements or tests conducted for the purpose of obtaining such data. Initial production test data including steam-water ratio, surface pressure and temperature, and quality and quantity of well effluent shall also be filed with the Supervisor on From 9-330C within 30 days after a well is completed.

D. Seismicity. The installation of seismographs or other like instruments in producing geothermal areas for the purpose of detecting potential seismic activity may be initiated from time to time by appropriate public agencies. Lessees shall cooperate with the appropriate public agencies in this regard. The lessee and the appropriate public agency should take care not to unreasonably interfere with or endanger each other's respective operations. The Supervisor shall coordinate such detection programs between the appropriate public agency conducting the program and the lessee.

Where induced seismicity caused by the production of geothermal fluids is determined to exist by the Supervisor, then the Supervisor may require the lessee to install such monitoring devices as necessary to adequately quantify the effects thereof. If induced seismicity is determined to represent a significant hazard, the Supervisor may require remedial actions including, but not limited to, reduced production rates, increased injection of waste or other fluids, or suspension of production.

9. Pollution and Waste Disposal. The lessee shall comply with all applicable Federal and state standards with respect to the control of all forms of air, land, water and noise pollution, including the control of erosion and the disposal of liquid, solid and gaseous wastes. The Supervisor may, at his discretion, establish additional and more stringent standards and, if he does so, the lessee shall comply with those standards. Plans for disposal of well effluents must be approved by the Supervisor before action is taken under them. Immediate corrective action shall be taken in all cases where pollution has occurred.

The lessee shall timely remove or dispose of all waste including human waste, trash, refuse and extraction and processing generated in connection with the lessee's operations in a manner acceptable to the Supervisor.

The lessee shall provide safeguards to minimize potential accidental fires and shall instruct field personnel in fire prevention methods. The lessee shall maintain fire-fighting equipment in working order at strategic locations on the leased lands.

A. Pollution Prevention. In the conduct of all geothermal operations, the lessee shall not contaminate any natural waters and shall minimize adverse effect on the environment.

(1) Liquid Disposal. Liquid well effluent or the liquid residue thereof containing substances, including heat, which may be harmful or injurious and cannot otherwise be disposed of in conformance with Federal,state and regional standards, shall be injected into the geothermal resources zone or such other formation as is approved by the Supervisor.

Toxic drilling fluids shall be disposed of in a manner approved by the Supervisor and in conformance with applicable Federal, state and regional standards.

(2) Solid Waste Disposal. Drill cuttings, sand, precipitates and other solids shall be disposed of as directed by the Supervisor either on location or at other approved disposal sites. Containers for mud additives or chemicals and other solid waste materials shall be disposed of in a manner and place approved by the Supervisor.

(3) Air Quality. Noncondensible gases such as carbon dioxide, ammonia and hydrogen sulfide may be vented or ejected into the atmosphere, provide however, that the volume and the measured concentration of such vented gas or gases shall not exceed applicable Federal, state or regional air pollution standards.

(4) Pits and Sumps. Pits and sumps shall be lined with impervious material and purged of environmentally harmful chemicals and precipitates before back-filling. In no event shall the contents of a pit or sump be allowed to contaminate streams, lakes and ground waters. Pits and sumps shll be constructed in a manner and in such locations so as to minimize damage to the natural environment and aesthetic values of the lease or adjacent property. When no longer used or useful, pits and sumps shall be back-filled and the premises restored to as near a natural state as reasonably possible. Temporary fencing of unattended pites and sumps to protect wildlife or personnel may be required by the Supervisor and the surface management agency.

(5) Production Facilities Maintenance. Production facilities shall be operated and maintained at all times in a manner necessary to

to prevent pollution. The lessee's field personnel shall be instructed in the proper maintenance and operation of production facilities for the prevention of pollution.

B. Inspections and Reports. Lessees shall comply with the following pollution inspection and reporting requirements.

(1) Pollution Inspections. Drilling and production facilities shall be inspected daily by the lessee. Appropriate preventative maintenance shall be performed as necessary to prevent failures and malfunctions which could lead to pollution. Wells and areas not under production shall be inspected by the lessee at intervals prescribed by the Supervisor. Necessary repairs or maintenance shall be made as required.

(2) Pollution Reports. All pollution incidents shall be reported orally within 18 hours to the appropriate Geothermal District Supervisor and shall be followed within 30 days thereof by a written report stating the cause and corrective action taken.

C. Injection. The use of any subsurface formation, including the geothermal resources zone, for well effluent disposal, the residue thereof or for the injection of fluids for other purposes such as subsidence prevention, shall not be permitted until the lessee has submitted a plan of injection covering the proposed injection project and has subsequently received the Supervisor's written approval thereof.

(1) Plan of Injection. The plan of injection shall include the quantity, quality and source of the proposed injection fluid; the means and method by which the fluid is to be injected; a structure map contoured on the intended injection zone; and cross-sections showing producing well locations and the proposed injection well location(s).

(2) Injection Report. The lessee shall file in duplicate with the Supervisor a Monthly Water Injection Report in a form approved by the Supervisor. The subject report shall be filed on or before the last day of the month following the month in which the injection took place.

(3) Inspection. Injection wells and facilities shall be inspected by the lessee at intervals as prescribed by the Supervisor to ascertain that all injected fluids are confined to the approved injection zone. A spinner survey, a radioactive tracer survey and a cement bond log may be required on each injection well within 30 days after injection begins. The lessee shall furnish to the Supervisor two legible exact copies of any and all such surveys and logs. In the event of a casing failure, inadequate annular cement or other mechanical failure, the lessee shall without unreasonable delay repair, suspend

or abandon the well. Where failure occurs in a zone which may damage surface or fresh water aquifers, injection shall immediately cease.

(4) New Wells. The drilling of new injection wells in accordance with an approved plan of injection shall be in conformance with the provisions of GRO Order No. 2. An Application for Permit to Drill, Form 9-331C, shall be filed in triplicate for each injection well.

(5) Conversions. The conversion of an existing well to an injection well in accordance with or modification of an approved plan of injection shall be in conformance with the requirements of GRO Order No. 2. The lessee shall demonstrate to the satisfaction of the Supervisor by appropriate testing and logging that the well is mechanically sound and suitable for injection purposes. A Sundry Notice, Form 9-331, shall be filed in triplicate for each conversion.

10. Water Quality. The primary responsibility for water quality and pollution control has been delegated to the states where such states have standards approved by the Environmental Protection Agency. Such states must meet basic Federal requirements prohibiting the deterioration of waters whose existing quality is higher than established water quality standards. The lessee shall comply with the state water quality control organization's standards in such states as have Federally approved standards. The Supervisor, at his discretion, may establish additional and more stringent standards.

The lessee shall file, in duplicate, a detailed water analysis report for all completed geothermal wells, upon completion and annually thereafter or as otherwise specified by the Supervisor. Unless otherwise prescribed by the Supervisor, such analyses shall include a determination of arsenic, boron, radioactive content and radioactivity of the produced fluids. In the event that a health hazard exists, the Supervisor shall require appropriate health and safety precautions, periodic monitoring, or the suspension of production.

11. Noise Abatement. The lessee shall minimize noise during exploration, development and production activities. The method and degree of noise abatement shall be as approved by the Supervisor.

The lessee shall conduct noise level measurements during exploration, development and production operations to determine the potential objectionability to nearby residents as well as the potential health and safety danger due to noise emissions.

Noise level measurements and accompanying data shall be filed with the Supervisor. Such data shall provide the basis for operational and noise control decisions by the Supervisor and shall be based on an assessment of the noise with respect to Federal or state criteria including adjustments for the area involved and the time of day of the noise occurrence.

The lessee shall comply with Federal occupational noise exposure levels applicable to geothermal activity under the Occupational Safety and Health Act of 1970 as set forth in 29 CFR 1910.95 incorporated herein by reference or with state standards for protection of personnel where such state standards are more restrictive than Federal standards.

A. Noise Measurement Conditions. Outdoor noise measurements shall be made at least 3 metres (10 feet) from structures, facilities or other sound reflecting sources and approximately 1 metre (3 feet) above ground level. Extreme weather conditions, electrical interference and unusual background noise levels shall be avoided or given due consideration when measuring sound levels.

B. Noise Measurements. The lessee shall monitor and measure noise levels using an octave band noise analyzer with an A-weighted frequency response or a standard sound level meter than conforms to the requirements set forth in USA Standard Specifications for General Purpose Sound Level Meters USASI S1.4-1961 or the latest approved revision thereof. Bandpass filters shall conform to the requirements of USASI S1.11-1966. The lessee shall measure noise level frequency distribution as required by the Supervisor. Sound levels shall be measured in conformance with the USA Standard Method for the Physical Measurement of Sound USASI S1.2-1962.

C. Noise Criteria. In the absence of more restrictive criteria as may be established in this paragraph, the lessee shall not exceed a noise level of 65 dB(A) for all geothermal-related activity including but not limited to, exploration, development or production operations as measured at the lease boundary line or 0.8 km (one-half mile) from the source, whichever is greater, using the A-weighted network of a standard Sound Level Meter. However, the permissible noise level of 65 dB(A) may be exceeded under emergency conditions or with the Supervisor's approval, if written permission is first obtained by the lessee from all residents within 0.8 km (one-half mile) who will be affected by the noise which is in excess of 65 dB(A).

D. Noise Assessment. The lessee shall be responsible for taking such noise level measurements as are deemed necessary by the Supervisor. The background noise level shall serve as the criterion for the rating and assessment, by the Supervisor, of the objectionableness of noise emission from a particular source. The background or ambient noise is defined hereby as the minimim sound level at the relevant place and time in the absence of the source noise and shall include consideration for the type of land use, the season, atmospheric conditions and the time of day.

E. Attenuation. To attenuate objectionable noise, the lessee shall utilize properly designated muffling devices as required by the Supervisor.

F. Relationships. Reference levels and realtionships for noise measurements shall be as follows:

(1) Reference sound pressure for airborne sounds shall be 20 MN/m^2 (20 micronewtons per square metre).

(2) Reference power shall be 10^{-12} watts.

(3) Sound levels shall be measured using a standard Sound Level Meter with an "A" frequency response characteristic (weighting network).

(4) Sound level meter controls shall be set for as uniform a frequency response as possible when measuring sound pressure levels.

(5) Octave band noise levels shall be reported in equivalent A-weighted levels.

B. Record of Sound Measurements. A record of sound level measurements shall be filed in duplicate with the Supervisor and shall include the following data:

(1) Date, time and location.

(2) Name of observer.

(3) Description of primary noise source emitter under test.

(4) Kind of operation and operating conditions.

(5) Description of secondary noise sources including location, type and kind of operation.

(6) Type and serial numbers on all microphones, sound level meters and octave band analyzers used. Length and type of microphone cables.

(7) Postion of observer.

(8) Direction of arrival of sound with respect to microphone orientation.

(9) Approximate temperature of microphone.

(10) Results of maintenance and calibration tests.

(11) Weighting network and meter speed used.

(12) Measured overall response and band levels at each microphone position and extent of meter fluctuation.

(13) Background overall response and band levels at each microphone position with primary noise source not operating.

(14) Cable and microphone corrections.

(15) Any other pertinent data such as personnel exposed directly and indirectly, time pattern of the exposure, atmospheric conditions, attempts at noise control and personnel protection.

Reid T. Stone
Area Geothermal Supervisor

Approved:

Russell G. Wayland
Chief, Conservation Division

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